



**Shell Chemical Yabucoa, Inc.**

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***Final RCRA Facility  
Investigation Report  
(Working Draft)***

***Shell Chemical Yabucoa, Inc.  
Yabucoa, Puerto Rico  
EPA ID No. PRD090074071***

***February 2007***

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**Final RFI Report (Working Draft)**  
**February 2007**

As discussed during a March 29, 2006 meeting with EPA and a follow-up letter from Sunoco dated April 10, 2006, this Final RFI Report (Working Draft) is being submitted to EPA for approval prior to preparing the Final RFI Report. It was SCYI's/Sunoco's understanding from the March 29 meeting that EPA will comment only on the revisions and that the remainder of the report as submitted to EPA in March 2005 RFI Report is acceptable. Sections 1 and 4, for which EPA did not provide any comment and consequently did not require change, are nevertheless included in the Working Draft for EPA's convenience.

Sections or portions of sections of the report that were revised as per EPA technical review comments, other than minor typographical edits, are shown in the text of the Working Draft as shaded.

All tables and figures, and updated Appendices J and K are included in the Working Draft.

EPA did not have any comments on Plates 1 and 2, and Appendices A through I. Consequently, they are not provided in the Working Draft.



## ***Table of Contents***

<b>1.0</b>	<b>Introduction .....</b>	<b>1-1</b>
1.1	Summary of RCRA Corrective Action Program .....	1-1
1.2	Report Organization .....	1-2
<b>2.0</b>	<b>Environmental Setting and Conceptual Model .....</b>	<b>2-1</b>
2.1	Facility Location .....	2-1
2.2	Facility Operations .....	2-2
2.3	Topography .....	2-4
2.4	Meteorology .....	2-4
2.5	Surface Water Hydrology .....	2-5
2.6	Regional Geology .....	2-6
2.7	Site-Specific Geology .....	2-7
2.8	Regional Hydrogeology .....	2-8
2.9	Site-Specific Hydrogeology .....	2-11
2.10	Tidal Influence .....	2-16
<b>3.0</b>	<b>Field Investigation Procedures .....</b>	<b>3-1</b>
3.1	Soil Sampling Procedures .....	3-1
3.2	Monitoring Well Installation Procedures .....	3-2
3.3	Groundwater Sampling Procedures .....	3-3
3.4	Analytical Methods and Quality Assurance/Quality Control .....	3-5
<b>4.0</b>	<b>Groundwater Flow and Vertical Gradient Evaluation .....</b>	<b>4-1</b>
4.1	Objective .....	4-1
4.2	Scope .....	4-1
4.3	Results .....	4-3

## ***Table of Contents (cont'd)***

<b>5.0</b>	<b>Field Investigation Program and Results</b>	<b>5-1</b>
5.1	Introduction	5-1
5.2	Background Soil and Groundwater Investigation	5-8
5.3	Final Retention Basin (SWMU 14)	5-10
5.4	North and South Aeration Basins (SWMUs 17 and 18)	5-12
5.5	Slop Oil Tank (SWMU 35)	5-15
5.6	Dissolved Air Flotation Unit (SWMU 36)	5-18
5.7	Dewatering Chamber (SWMU 38)	5-21
5.8	Hazardous Waste Mixing Box (SWMU 39)	5-24
5.9	Northeast Refinery Area (SWMU 40)	5-27
5.10	West API Separator (SWMU 2)	5-37
5.11	East API Separator (SWMU 3)	5-40
5.12	Watery Oil Separator (SWMU 43)	5-45
5.13	Ballast Basin Skimmer Area (SWMU 44)	5-50
5.14	Ballast Basin Leachate Collection Tank (SWMU 44A)	5-53
5.15	East Aisle Ditch (SWMU 45)	5-55
5.16	Main Dock Sump (SWMU 33)	5-59
5.17	Barge Dock Sump (SWMU 34)	5-65
5.18	Data Quality	5-71
<b>6.0</b>	<b>Contaminant Fate and Transport</b>	<b>6-1</b>
6.1	Organic Compounds	6-1
6.2	Inorganic Compounds	6-3
6.3	Residual Petroleum Product	6-6
<b>7.0</b>	<b>Exposure Assessment</b>	<b>7-1</b>
7.1	Potentially Exposed Human Populations	7-1
7.2	Potential Migration Pathways and Human Receptors	7-2
7.3	Ecological Evaluation	7-14

## ***Table of Contents (cont'd)***

<b>8.0</b>	<b>Conclusions .....</b>	<b>8-1</b>
<b>9.0</b>	<b>References .....</b>	<b>9-1</b>

## ***List of Tables***

- 2-1. Construction Details of Production Wells
- 2-2. Groundwater Levels at USGS Nested Monitoring Wells
- 2-3. Groundwater Elevation Summary at the Northeast Refinery Area (September 1996)
- 2-4. Groundwater Elevation Summary (January 1997)
- 2-5. Surface Water Elevation Summary at the Northeast Refinery Area
  
- 4-1. Construction Details of RFI Wells
- 4-2. Construction Details of Existing Facility Wells
- 4-3. Site-Wide Groundwater Elevation Summary (August/September 1996)
- 4-4. Groundwater Elevation Summary (April 2003)
- 4-5. Water Levels at Nested Wells for Vertical Gradient Evaluation (2003)
  
- 5-1. Metal Concentrations in Background Soil Samples.
- 5-2. Concentrations of Metals in Soil Samples collected by Geraghty & Miller, Inc. June 1992
- 5-3. Background Levels of Metals in Soil.
- 5-4. BTEX Concentrations in Groundwater, Upgradient Wells (DA-1 and RA-8).
- 5-5. VOC Concentrations in Groundwater, Final Retention Basin.
- 5-6. BNA Concentrations in Groundwater, Final Retention Basin.
- 5-7. Metal Concentrations in Groundwater, Final Retention Basin.
- 5-8. VOC Concentrations in Groundwater, North Aeration Basin.
- 5-9. VOC Concentrations in Groundwater, South Aeration Basin.
- 5-10. BNA Concentrations in Groundwater, North Aeration Basin.
- 5-11. BNA Concentrations in Groundwater, South Aeration Basin.
- 5-12. Metal Concentrations in Groundwater, North Aeration Basin.
- 5-13. Metal Concentrations in Groundwater, South Aeration Basin.
- 5-14. VOC Concentrations in Surface Soil, Slop Oil Tank.
- 5-15. VOC Concentrations in Subsurface Soil, Slop Oil Tank.
- 5-16. BNA Concentrations in Surface Soil, Slop Oil Tank.
- 5-17. BNA Concentrations in Subsurface Soil, Slop Oil Tank.
- 5-18. Metal Concentrations in Surface Soil, Slop Oil Tank.
- 5-19. Metal Concentrations in Subsurface Soil, Slop Oil Tank.
- 5-20. Immunoassay Field Screening Results, Slop Oil Tank.
- 5-21. VOC Concentrations in Surface Soil, Dissolved Air Flotation Unit.
- 5-22. VOC Concentrations in Subsurface Soil, Dissolved Air Flotation Unit.

## ***List of Tables (cont'd)***

- 5-23. BNA Concentrations in Surface Soil, Dissolved Air Flotation Unit.
- 5-24. BNA Concentrations in Subsurface Soil, Dissolved Air Flotation Unit.
- 5-25. Metal Concentrations in Surface Soil, Dissolved Air Flotation Unit.
- 5-26. Metal Concentrations in Subsurface Soil, Dissolved Air Flotation Unit.
- 5-27. Immunoassay Field Screening Results, Dissolved Air Flotation Unit.
- 5-28. VOC Concentrations in Surface Soil, Dewatering Chamber.
- 5-29. VOC Concentrations in Subsurface Soil, Dewatering Chamber.
- 5-30. BNA Concentrations in Surface Soil, Dewatering Chamber.
- 5-31. BNA Concentrations in Subsurface Soil, Dewatering Chamber.
- 5-32. Metal Concentrations in Surface Soil, Dewatering Chamber.
- 5-33. Metal Concentrations in Subsurface Soil, Dewatering Chamber.
- 5-34. VOC Concentrations in Groundwater, Dewatering Chamber.
- 5-35. BNA Concentrations in Groundwater, Dewatering Chamber.
- 5-36. Metal Concentrations in Groundwater, Dewatering Chamber.
- 5-37. Immunoassay Field Screening Results, Dewatering Chamber.
- 5-38. VOC Concentrations in Subsurface Soil, Hazardous Waste Mixing Box.
- 5-39. BNA Concentrations in Surface Soil, Hazardous Waste Mixing Box.
- 5-40. BNA Concentrations in Subsurface Soil, Hazardous Waste Mixing Box.
- 5-41. Metal Concentrations in Surface Soil, Hazardous Waste Mixing Box.
- 5-42. Metal Concentrations in Subsurface Soil, Hazardous Waste Mixing Box.
- 5-43. Immunoassay Field Screening Results, Hazardous Waste Mixing Box.
- 5-44. VOC Concentrations in Surface Soil, North East Refinery Area.
- 5-45. VOC Concentrations in Subsurface Soil, North East Refinery Area.
- 5-46. BNA Concentrations in Surface Soil, North East Refinery Area.
- 5-47. BNA Concentrations in Subsurface Soil, North East Refinery Area.
- 5-48. Metal Concentrations in Surface Soil, North East Refinery Area.
- 5-49. Metal Concentrations in Subsurface Soil, North East Refinery Area.
- 5-50. VOC Concentrations in Groundwater, North East Refinery Area.
- 5-51. BNA Concentrations in Groundwater, North East Refinery Area.
- 5-52. Metal Concentrations in Groundwater, North East Refinery Area.
- 5-53. Immunoassay Field Screening Results, North East Refinery Area.
- 5-54. Summary of Free Product Apparent Thickness, North East Refinery Area.
- 5-55. VOC Concentration in Sediment, Lajas Creek.
- 5-56. PAH Concentration in Sediment, Lajas Creek.
- 5-57. VOC Concentration in Surface Water, Lajas Creek.
- 5-58. BNA Concentration in Surface Water, Lajas Creek.

## ***List of Tables (cont'd)***

- 5-59. VOC Concentrations in Surface Soil, West API Separator.
- 5-60. VOC Concentrations in Subsurface Soil, West API Separator.
- 5-61. BNA Concentrations in Surface Soil, West API Separator.
- 5-62. BNA Concentrations in Subsurface Soil, West API Separator.
- 5-63. Metal Concentrations in Surface Soil, West API Separator.
- 5-64. Metal Concentrations in Subsurface Soil, West API Separator.
- 5-65. VOC Concentrations in Groundwater, West API Separator.
- 5-66. BNA Concentrations in Groundwater, West API Separator.
- 5-67. Metal Concentrations in Groundwater, West API Separator.
- 5-68. Immunoassay Field Screening Results, West API Separator.
- 5-69. VOC Concentrations in Surface Soil, East API Separator.
- 5-70. VOC Concentrations in Subsurface Soil, East API Separator.
- 5-71. BNA Compound Concentrations in Surface Soil, East API Separator.
- 5-72. BNA Compound Concentrations in Subsurface Soil, East API Separator.
- 5-73. Metal Concentrations in Surface Soil, East API Separator.
- 5-74. Metal Concentrations in Subsurface Soil, East API Separator.
- 5-75. VOC Concentrations in Groundwater, East API Separator.
- 5-76. BNA Concentrations in Groundwater, East API Separator.
- 5-77. Metal Concentrations in Groundwater, East API Separator.
- 5-78. Immunoassay Field Screening Results, East API Separator.
- 5-79. Summary of Free Product Apparent Thickness, East API Separator.
- 5-80. VOC Concentrations in Surface Soil, Watery Oil Separator.
- 5-81. VOC Concentrations in Subsurface Soil, Watery Oil Separator.
- 5-82. BNA Compound Concentrations in Subsurface Soil, Watery Oil Separator.
- 5-83. Metal Concentrations in Subsurface Soil, Watery Oil Separator.
- 5-84. VOC Concentrations in Groundwater, Watery Oil Separator.
- 5-85. BNA Concentrations in Groundwater, Watery Oil Separator.
- 5-86. Metal Concentrations in Groundwater, Watery Oil Separator.
- 5-87. Immunoassay Field Screening Results, Watery Oil Separator.
- 5-88. Summary of Free Product Apparent Thickness, Watery Oil Separator.
- 5-89. VOC Concentrations in Surface Soil, Ballast Basin Skimmer Area.
- 5-90. VOC Concentrations in Subsurface Soil, Ballast Basin Skimmer Area.
- 5-91. BNA Concentrations in Surface Soil, Ballast Basin Skimmer Area.
- 5-92. BNA Concentrations in Subsurface Soil, Ballast Basin Skimmer Area.
- 5-93. Metal Concentrations in Surface Soil, Ballast Basin Skimmer Area.
- 5-94. Metal Concentrations in Subsurface Soil, Ballast Basin Skimmer Area.

## ***List of Tables (cont'd)***

- 5-95. VOC Concentrations in Groundwater, Ballast Basin Skimmer Area.
- 5-96. BNA Concentrations in Groundwater, Ballast Basin Skimmer Area.
- 5-97. Metal Concentrations in Groundwater, Ballast Basin Skimmer Area.
- 5-98. Immunoassay Field Screening Results, Ballast Basin Skimmer Area.
- 5-99. VOC Concentrations in Surface Soil, East Aisle Ditch.
- 5-100. VOC Concentrations in Subsurface Soil, East Aisle Ditch.
- 5-101. BNA Concentrations in Surface Soil, East Aisle Ditch.
- 5-102. BNA Concentrations in Subsurface Soil, East Aisle Ditch.
- 5-103. Metal Concentrations in Surface Soil, East Aisle Ditch.
- 5-104. Metal Concentrations in Subsurface Soil, East Aisle Ditch.
- 5-105. VOC Concentrations in Groundwater, East Aisle Ditch.
- 5-106. BNA Compound Concentrations in Groundwater, East Aisle Ditch.
- 5-107. Metal Concentrations in Groundwater, East Aisle Ditch.
- 5-108. Immunoassay Field Screening Results, East Aisle Ditch.
- 5-109. Summary of Free Product Apparent Thickness, East Aisle Ditch.
- 5-110. VOC Concentrations in Groundwater, Main Dock Sump.
- 5-111. BNA Concentrations in Groundwater, Main Dock Sump.
- 5-112. Metal Concentrations in Groundwater, Main Dock Sump.
- 5-113. Summary of Free Product Apparent Thickness, Main Dock Sump.
- 5-114. VOC Concentration in Surface Water, Main Dock Sump.
- 5-115. BNA Concentration in Surface Water, Main Dock Sump.
- 5-116. Metal Concentration in Surface Water, Main Dock Sump.
- 5-117. VOC Concentrations in Surface Soil, Barge Dock Sump.
- 5-118. VOC Concentrations in Subsurface Soil, Barge Dock Sump.
- 5-119. BNA Concentrations in Surface Soil, Barge Dock Sump.
- 5-120. BNA Concentrations in Subsurface Soil, Barge Dock Sump.
- 5-121. Metal Concentrations in Surface Soil, Barge Dock Sump.
- 5-122. Metal Concentrations in Subsurface Soil, Barge Dock Sump.
- 5-123. VOC Concentrations in Groundwater, Barge Dock Sump.
- 5-124. BNA Concentrations in Groundwater, Barge Dock Sump.
- 5-125. Metal Concentrations in Groundwater, Barge Dock Sump.
- 5-126. Immunoassay Field Screening Results, Barge Dock Sump.
- 5-127. Summary of Free Product Apparent Thickness, Barge Dock Sump.

## **6-1 Chemical and Physical Characteristics of Constituents of Concern**

## ***List of Tables (cont'd)***

- 7-1 Maximum Detections in Surface Soil
- 7-2 Maximum Detections in Subsurface Soil
- 7-3 Detections in Surface and Subsurface Soil above RBSLs
- 7-4 Maximum Detections in Groundwater
- 7-5 Detections in Groundwater Above Screening Levels
- 7-6 Flora and Fauna in the Yabucoa Area including Endangered and Threatened Species
- 7-7 Selection of ESLs for Metals
- 7-8 Maximum Concentrations of VOCs, BNAs, and Metals in Surface Soil with Respect to ESLs
- 7-9 Comparison of ESLs to Maximum Detection Limits for Non-Detects in Surface Soil



## ***List of Figures***

- 2-1 Facility Location
- 2-2 Facility Site Map
- 2-3 Refinery Area Site Map
- 2-4 Tank Farm Site Plan
- 2-5 Dock Area Site Map
- 2-6 Bedrock Elevation Map
- 2-7 Geologic Cross-Section A-A'
- 2-8 Geologic Cross-Section B-B'
- 2-9 Geologic Cross-Section C-C'
- 2-10 Geologic Cross-Section D-D'
- 2-11 Geologic Cross-Section E-E'
- 2-12 Location of Facility Production Wells
- 2-13 Regional Groundwater Elevation and Flow Direction Map (Pre development)
- 2-14 Regional Groundwater Elevation and Flow Direction Map (1990)
- 2-15 Groundwater Levels at USGS Well TW-2
- 2-16 Location of USGS Nested Groundwater Monitoring Wells
- 2-17 Site-Specific Groundwater Elevation and Flow Direction Map (1996)
- 2-18 Site-Specific Groundwater Elevation and Flow Direction Map (2003)
- 2-19 Groundwater and Creek Monitoring Locations at the Northeast Refinery Area (2003)
- 2-20 Tides - Roosevelt Roads
- 2-21 Location of Monitoring Wells for Tidal Groundwater Level Measurements
- 2-22 Tidal Fluctuations at Well MDS-8
- 2-23 Tidal Fluctuations at Well BDS-1
- 2-24 Tidal Fluctuations at Well DA-1

## ***List of Figures (cont'd)***

- 5-1 Locations of Solid Waste Management Units (SWMUs)
- 5-2 Background Soil and Groundwater Sampling Locations
- 5-3 Final Retention Basin, Groundwater Sampling Results
- 5-4 N. & S. Aeration Basins, Groundwater Sampling Results
- 5-5 Slop Oil Tank 103, Soil Sampling Results
- 5-6 DAF Unit, Soil Sampling Results
- 5-7 Dewatering Chamber, Soil Sampling Results
- 5-8 Dewatering Chamber, Groundwater Sampling Results
- 5-9 Hazardous Waste Mixing Box, Soil Sampling Results
- 5-10 North East Refinery Area, Soil Sampling Results
- 5-11 North East Refinery Area, Groundwater Sampling Results
- 5-12A North East Refinery Area, Apparent Free Product Thickness 1997
- 5-12B North East Refinery Area, Apparent Free Product Thickness 2001
- 5-12C North East Refinery Area, Apparent Free Product Thickness 2005
- 5-13 West API Separator, Soil Sampling Results
- 5-14 West API Separator, Groundwater Sampling Results
- 5-15 East API Separator, Soil Sampling Results
- 5-16 East API Separator, Groundwater Sampling Results
- 5-17A East API Separator, Apparent Free Product Thickness 1997
- 5-17B East API Separator, Apparent Free Product Thickness 2001
- 5-17C East API Separator, Apparent Free Product Thickness 2005
- 5-18 Watery Oil Separator, Soil Sampling Results
- 5-19 Watery Oil Separator, Groundwater Sampling Results
- 5-20A Watery Oil Separator, Apparent Free Product Thickness 1997
- 5-20B Watery Oil Separator, Apparent Free Product Thickness 2001
- 5-20C Watery Oil Separator, Apparent Free Product Thickness 2005
- 5-21 Ballast Basin Skimmer Area, Soil Sampling Results
- 5-22 Ballast Basin Skimmer Area, Groundwater Sampling Results
- 5-23 Leachate Collection Tank, Location Map
- 5-24 East Aisle Ditch, Soil Sampling Results
- 5-25 East Aisle Ditch, Groundwater Sampling Results

## ***List of Figures (cont'd)***

- 5-26A East Aisle Ditch, Apparent Free Product Thickness 1997
- 5-26B East Aisle Ditch, Apparent Free Product Thickness 2001
- 5-26C East Aisle Ditch, Apparent Free Product Thickness 2005
- 5-27 Main Dock Sump, Groundwater Sampling Results
- 5-28A Main Dock Sump, Apparent Free Product Thickness 1997
- 5-28B Main Dock Sump, Apparent Free Product Thickness 2001
- 5-28C Main Dock Sump, Apparent Free Product Thickness 2005
- 5-29 Barge Dock Sump, Soil Sampling Results
- 5-30 Barge Dock Sump, Groundwater Sampling Results
- 5-31A Barge Dock Sump, Apparent Free Product Thickness 1997
- 5-31B Barge Dock Sump, Apparent Free Product Thickness 2001
- 5-31C Barge Dock Sump, Apparent Free Product Thickness 2005
  
- 7-1 Wetlands Map
- 7-2 Environmental Sensitivity Index Map

## ***Plates***

1. Location Map of Historical Borings Drilled Prior to the RFI and Location of Geologic Cross-Sections
2. Groundwater Level Monitoring Locations

## ***Appendices***

Appendix A	Historical Boring Logs Prior to RFI
Appendix B	Surveyor's Report
Appendix C	Aquifer Testing Results and Miscellaneous Groundwater Sampling Data
Appendix D	Soil Boring Logs
Appendix E	Well Construction Logs
Appendix F	Groundwater Sampling Field Data Sheets
Appendix G	Metal Concentrations in Background Soil Samples
Appendix H	Physiochemical Soil Results
Appendix I	Free Product Testing Results
Appendix J	Data Validation Reports
Appendix K	Threatened/Endangered Species and Critical Habitats Database Search

## **1.0 Introduction**

### **1.1 Summary of RCRA Corrective Action Program**

A RCRA Facility Investigation (RFI) has been completed at the Shell Chemical Yabucoa Inc. (formerly Puerto Rico Sun Oil Company, PRSOC) petroleum refining facility located in Yabucoa, Puerto Rico. The RFI was implemented to satisfy the terms of the RCRA 3008(h) Corrective Action Order (Order) signed by PRSOC and the United States Environmental Protection Agency (EPA) in June 1994. Sunoco Inc. (Sunoco) of Philadelphia, PA sold its PRSOC facility to Shell Chemical Yabucoa Inc. (SCYI), on December 31, 2001. However, Sunoco is performing the RFI work on behalf of SCYI.

The RFI was conducted in accordance with the terms of the RCRA Facility Investigation Work Plan (AMAI, 1994), which was initially submitted to EPA in October 1994 and approved by EPA, with certain revisions, in April 1996. The RFI included the investigation of soil and/or groundwater at 16 solid waste management units (SWMUs) identified in the Order. A Process Sewer Assessment was also performed in accordance with the terms of the Order. The report for the Process Sewer Assessment was submitted to EPA in October 1997 (AMAI, 1997).

The objectives of the RFI are summarized below:

- To identify hazardous constituents and their concentrations in soil and/or groundwater at the subject SWMUs
- To determine the potential for contaminant migration by assessing site-specific and regional characteristics that are likely to affect contaminant migration
- To acquire sufficient data to characterize environmental contamination at the SWMUs to support interim or long-term corrective measures, if necessary
- To acquire sufficient data to assess any potential risk to human health and the environment

RFI field activities were conducted between June and August 1996 with certain follow-on activities conducted in January 1997. A Draft RFI Report (AMAI, 1997), which summarized the results of the RFI, was submitted to EPA in June 1997.

In response to EPA comments on the Draft RFI Report, PRSOC submitted a Supplemental RFI Work Plan in March 1999. The objective of the Supplemental RFI was to address a number of data gaps identified by EPA. The Supplemental RFI Work Plan was approved by EPA, with certain revisions, in November 2002 (AMAI, 2002). Supplemental background soil sampling locations were approved by EPA in March 2003. Supplemental RFI field activities were conducted between January and June 2003. A Supplemental RFI Report, which presented the results of the supplemental investigation, was submitted to EPA in June 2003 (AMAI, 2003).

This Final RFI Report consolidates the findings presented in the 1997 Draft RFI Report and the 2003 Supplemental RFI Report. The report also addresses comments provided by EPA in its letter dated November 23, 2004. With this submission, SCYI has satisfied the provisions of Section VI.1 of the 1994 Corrective Action Order.

## **1.2 Report Organization**

A brief description of the organization and content of the remaining sections of this report is presented below.

Section 2 - Section 2 provides a description of SCYI facility operations and the environmental setting of the facility, including topography, meteorology and surface water hydrology as well as regional and site-specific geology and hydrogeology. This information is used as the basis for the conceptual site model of the facility.

Section 3 - Section 3 provides a description of field and laboratory procedures employed in conducting the RFI.

Section 4 - Section 4 presents the results of the groundwater flow and vertical gradient study conducted as part of the RFI.

Section 5 - Section 5 provides a summary of the scope of the RFI field activities and presents the results of the RFI. An overview of soil and groundwater sampling activities

at each SWMU is presented. Results of soil and groundwater sampling and analysis activities are discussed on a SWMU-specific basis. Analytical results are presented in tabular and graphic format.

Section 6 - The mechanisms that influence the fate and transport of organic and inorganic chemicals in the subsurface are discussed in Section 6. The discussion focuses on those chemicals identified at the facility during the RFI.

Section 7 - Section 7 presents a preliminary exposure assessment of the facility based on the results of the RFI. The assessment includes an evaluation of potential migration pathways and potential impacts on human health and the environment.

Section 8 - Findings and conclusions relating to the nature and extent of contamination at the facility are summarized in Section 8.

Section 9 - Section 9 presents references used in development of the report.

## **2.0 Environmental Setting and Conceptual Model**

The environmental setting at the SCYI facility is presented in this section to provide the geologic and hydrogeologic basis for the conceptual site-wide model (CSM). This information along with the contamination assessment addressed in Section 5 of this report defines the CSM. The CSM is used to evaluate site conditions and any contamination scenarios that could lead to an unacceptable threat or exposure at the site. Items discussed include topography, meteorology, surface water characteristics, regional and site-specific geology and hydrogeology, and tidal influences on groundwater level and flow. A description of facility operations is also presented.

This section also presents groundwater level data that were collected during the RFI in 1996-1997 and 2003. Groundwater level data results collected during the Supplemental RFI in 2003 are discussed in more detail in Section 4. Specific geologic, hydrogeologic, and contamination results for the Solid Waste Management Units (SWMUs) investigated during the RFI are discussed in Section 5.

### **2.1 Facility Location**

The SCYI facility is located on Route 901, Km 2.7, Camino Nuevo Ward, about 1.5 miles east of the town of Yabucoa, Puerto Rico. The facility occupies an area of approximately 252 acres which is sub-divided into three working areas: the Refinery Area, the Tank Farm Area, and the Dock Area. The Refinery Area is the most inland area of the facility; the Tank Farm Area is about 2,300 ft east toward the Caribbean Sea; and the Dock Area is further to the east and terminates at the Caribbean Sea. The Dock Area encloses a small man-made inlet (previously referred to as the Turning Basin) which the facility uses for sea transportation purposes.

Maps showing the location of the SCYI facility with respect to the surrounding community, the location of the Refinery, Tank Farm and Dock Areas, and site plans for the Refinery, Tank Farm, and Dock Areas are presented in Figures 2-1 through 2-5. Maps showing the location of the various SWMUs within the Refinery, Tank Farm, and Dock Areas are presented in Figures 2-3 through 2-5. **Figure 5-1 shows the locations of the various SWMUs at the facility.**

Agricultural and sugar cane fields surround the facility to the north, east, and west. Route 901 borders the Refinery Area to the south. Route 53 traverses between the Refinery and Tank Farm



Areas. Sugar cane fields are to the south of the Tank Farm Area and a palm tree grove and beach are to the south of the Dock Area. A mountainous area is situated further south of the facility.

The nearest populated area to the facility is the residential community of Camino Nuevo, which has a population of about 4,900, the center of which is located about 2,500 ft southeast of the Refinery Area. The city of Yabucoa is located about 1.5 miles west of the facility.

## **2.2 Facility Operations**

Petroleum refining operations at the facility commenced in May 1971. Prior to the construction of the facility, the property was used as agricultural land. SCYI leases the property upon which the facility is constructed from the Commonwealth of Puerto Rico. Prior to the sale of the facility to SCYI on December 31, 2001, the facility was operated by Puerto Rico Sun Oil Company (PRSOC). There have been no other changes in ownership of the facility.

While operated by PRSOC, the facility complex historically processed 85,000 barrels per day of crude oil. Major products included: reformat, kerosene, light distillates, white oil, naphtha, jet fuel, diesel fuel, No. 2 fuel oil, desulfurized gas oil, lube oil base stocks, residual fuels, aromatic extracts, slack wax and sulfur. Reduced operations occurred between June 2000 and June 2001. The refinery temporarily ceased operation in June 2001, prior to the ownership change in December 2001 to SCYI. After resumption of refinery operations in April 2002 by SCYI, the facility began daily processing of about 75,000 barrels of crude oil to produce gasoline, kerosene aviation fuel, diesel, residual oil, and hydrotreated gas oils for use by Olefin Plants at other facilities for chemical production.

Operations at the SCYI facility are conducted at the three distinct areas mentioned above - the Refinery Area, the Tank Farm and the Dock Area. The three areas are interconnected by a series of above ground pipelines. Further information on each of the areas is provided below.

Refinery Area - The Refinery Area includes SCYI's oil processing operations. The following process units are located at the Refinery Area: crude unit, gas oil desulfurizer, hydrogen unit, sulfur unit, hydrotreater and feed preparation unit, MEK dewaxing unit, UV stabilization and final distillation unit, gasoline reformer and utilities. The MEK dewaxing unit, and UV stabilization and final distillation unit have not been in operation since SCYI acquired the facility in December 2001, however. The Refinery Area also

includes tank storage facilities, administrative and maintenance operations and a waste storage and treatment facility. Figure 2-3 presents a site plan of the Refinery Area. The Refinery Area Wastewater Treatment Plant is located in the northern portion of the Refinery Area.

Tank Farm - Raw materials and products manufactured by SCYI are stored in above ground steel tanks in the Tank Farm Area. Materials are conveyed to and from the Tank Farm via above ground pipelines. The Tank Farm contains approximately 43 crude and product tanks, ranging in size from 500 to 375,000 barrels. Historically, there have been three storage tanks associated with SCYI's ballast water and slop oil management systems. However, SCYI agreed with EPA to remove ballast water handling from SCYI's NPDES permit. As a consequence, ballast water is no longer managed at the Tank Farm Wastewater Treatment Plant, and only one storage tank for slop oil management is used. A tanker truck loading rack is located near the southwestern corner of the Tank Farm. Figure 2-4 includes a site plan of the Tank Farm. The Tank Farm Wastewater Treatment Plant is located in the southeast corner of the Tank Farm.

Dock Facility - SCYI operates a dock facility for the loading and unloading of crude oil and products. The facility includes a Main Dock which serves oil tankers and a Barge Dock which serves smaller vessels and barges. There is also a dock for the servicing of tugboats. Crude oil and products are transferred to and from the Dock Area via aboveground pipelines. There are no storage facilities, process units or any other operations conducted at the Dock Area. Figure 2-5 includes a site plan of the Dock Area.

The SCYI facility is served by several different wastewater collection and treatment systems. The systems are designed to reduce the volume of contaminated wastewater requiring treatment by segregating contaminated and uncontaminated wastewater to the maximum extent possible. At the Refinery Area, collection systems exist for contaminated process wastewater, contaminated stormwater, uncontaminated stormwater, and sanitary wastewater. At the Tank Farm, a collection system is provided for stormwater and tank water drawoff. Collection systems are provided for stormwater at both the Main Dock and the Barge Dock.

Flood protection is provided around the SCYI facility by a series of ditches and earthen dikes. This prevents stormwater from flowing onto the facility property from off-site areas. It also prevents stormwater falling on the SCYI site from flowing onto surrounding land areas.

SCYI has been issued a National Pollution Discharge Elimination System (NPDES) Permit for the discharge of wastewater and stormwater into area surface waters. The Permit allows the discharge of treated process wastewater into the Caribbean Sea through Outfall 001 and the discharge of uncontaminated stormwater into Santiago Creek through Outfall 002. The locations of Outfalls 001 and 002 are shown in Figures 2-5 and 2-3, respectively.

## **2.3 Topography**

The SCYI facility is located within the Yabucoa valley which is surrounded by mountains on three sides and is bordered to the east by the Caribbean Sea. Relatively short rivers and streams originate from the surrounding mountains, traverse the valley, and discharge to the Caribbean Sea.

The altitude of land surface within a 3-mile radius of the facility ranges from sea level to more than 1770 ft above mean sea level (amsl) in the mountains to the south. The highest mountain peak within this radius is Cerro Santa Elena, which is located about 1.6 miles southwest of the Refinery Area. The elevation of the central part of Yabucoa valley north of the Refinery Area is about 16 ft amsl.

The general elevation across the facility increases from northeast to southwest and ranges from sea level at the Dock Area to about 42 feet amsl at the southwestern boundary of the Refinery Area. The average elevations of the Refinery Area, Tank Farm Area, and Dock Area are about 18 ft, 7 ft, and 3 ft amsl, respectively. Topographic relief within the facility areas is mild.

## **2.4 Meteorology**

The climate of Puerto Rico is tropical and is influenced by easterly trade winds which are modified by local land and sea breezes. The easterly winds carry moist air from the east, which rises and cools as it moves inland causing rain showers. The weather from May to November is characterized by cloudiness and rain, occasional tropical storms, flooding rains, and hurricanes. Typically, January through April are the driest months and May through November are the wettest. The average seawater temperature surrounding Puerto Rico, which moderates the climate, is about 27°C (81°F), with little variation throughout the year. The relative humidity over the island averages about 80% during the course of the year.

National Oceanic and Atmospheric Administration (NOAA) climatological data for Yabucoa for a six-year period from 1987 through 1992 showed that rainfall ranged from about 63 to 107 inches, with an average of about 78 inches. The greatest daily rainfall during the six-year period was 10.9 inches. The average rainfall at Yabucoa is somewhat greater than the 30-year island wide annual rainfall average of about 63 inches. Temperature during the six-year period ranged from about 63°F to 91°F, with an average annual temperature of about 78°F. Based on 1993 data, the estimated annual evaporation was 66 inches. Monthly evaporation ranged from 3.4 inches in January 1993 to 7.5 inches in August 1993. The predominant wind direction was from the southeast.

## **2.5 Surface Water Hydrology**

The main inland surface water feature of the Yabucoa valley is the Guayanés River which is located about 1.4 miles northeast of the SCYI facility. The Guayanés, which flows mainly along the east-west axis of Yabucoa Valley, discharges to the Caribbean Sea north of the Dock Area. Surface water flow in the valley is generally from west to east toward the sea. Surface water features are shown in Figure 2-1 and Plate 2.

The nearest surface water features to the facility are Lajas Creek which runs along the eastern border of the Refinery Area and Santiago Creek which runs along the northern border of the Refinery Area. Lajas Creek subsequently enters Santiago Creek about 300 feet north of the Refinery Area. Santiago Creek runs eastward along the northern part of the Refinery Area and discharges to the Caribbean Sea about 1.5 miles to the east. A small unnamed creek runs generally east-west near the northern border of the Tank Farm Area. This creek is also a tributary to Santiago Creek. A second small unnamed creek runs in a northeasterly direction south of the Tank Farm Area. This creek discharges directly to the Caribbean Sea. None of the rivers or streams in the valley are navigable by large vessels. No discharge flow records were available for any of the creeks or rivers.

The largest surface water body in the area is the Caribbean Sea which borders the Dock Area and is about 1.5 miles east of the Refinery Area. In the Dock Area, a small man-made inlet from the Caribbean Sea is used by tanker ships for loading/unloading operations.

The SCYI facility was located within the 100-year flood plain according to the FEMA flood plain map of the area. SCYI built flood control levees to protect the facility areas from potential flood events. The height of these levees exceeds the 100-year flood level.

Stormwater runoff from the refinery process area is intercepted by an underground storm-sewer system; in the Tank Farm Area it is intercepted by the East and West Aisle drainage ditches. Stormwater is also intercepted in the Dock Area.

## **2.6 Regional Geology**

The SCYI facility is situated in the southeastern portion of the Yabucoa valley in southeastern Puerto Rico. The valley, which has a drainage area of about 45 square miles, is surrounded by weathered diorite hills, except towards its eastern margin where it is bordered by the Caribbean Sea. The valley is underlain by a series of complex alluvial deposits comprised of coarse-grained stream channel deposits, finer grained natural levee deposits, and clay-sized sediments typical of flood plain deposits. The alluvial deposits, which occur mainly in the central portion of the valley, cover an area of approximately 15 square miles. The underlying bedrock is composed of diorite and granodiorite bedrock which is weathered to varying degrees.

The inland alluvial deposits grade into coastal marine sediments eastward towards the Caribbean Sea. The alluvium is more than 300 feet thick in the center of the valley and thins toward the hills to the south where the facility is located. Within the alluvial deposits are water-bearing sand strata and lenses of limited areal extent. Bedrock elevations for the eastern portion of the Yabucoa valley determined by the U.S. Geological Survey from borehole and geophysical data (USGS, 1996a) are illustrated in Figure 2-6. Buried bedrock ridges have been identified in the area; one of these ridges trends northeast-southwest through the eastern portion of the Refinery Area to the west of the Tank Farm Area. A bedrock ridge also extends southwestward from the northeastern side of the valley. The bedrock map indicates that a paleochannel is incised in the bedrock between the two ridges roughly parallel to Santiago Creek, with the channel widening further inland.

The upper portion of diorite bedrock has been extensively weathered. The zone of weathered bedrock is about 20 to 50 feet thick. In some areas, the weathered bedrock consists of a crumbly mixture of sand, silt, and clay; in other areas the bedrock has decomposed to clay.

## 2.7 Site-Specific Geology

The site-specific geology at the SCYI facility is illustrated by five geologic cross-sections constructed across the site. The locations of the five cross-sections, which are identified as cross-sections A-A' through E-E', are shown on Plate 1. The individual cross-sections are presented as Figures 2-7 through 2-11. Geologic cross-sections A-A' and B-B', which are presented as Figures 2-7 and 2-8, respectively, are oriented west to east and begin near the Refinery Area and end at the Dock Area. Cross-sections C-C', D-D', and E-E', which are presented as Figures 2-9, 2-10, and 2-11, respectively, are oriented north to south and begin north of the facility and end near the foothills south of the facility. Cross-section C-C' (Figure 2-9) extends northward to near the center of Yabucoa valley. The geologic divisions shown on the cross-sections were derived from the Unified Soil Classification (USC) system. The USC system was also used for description of soil samples collected during the RFI.

Plate 1 also shows the locations of the borings used to construct the cross-sections and other historical borings which illustrate the deeper geology of the area. All geologic cross-sections described above were derived from pre-existing wells and engineering investigation borings that were installed prior to the RFI. Appendix A presents the historical boring logs.

The depth to bedrock increases from the southern diorite hills to the north toward the center of the valley as illustrated in cross-section C-C' (Figure 2-9). Near the center of Yabucoa Valley the depth to bedrock is over 200 ft. The depth to bedrock also increases eastward toward the Caribbean Sea beneath the Tank Farm and Dock Areas. The depth to bedrock is over 100 ft at the Dock Area.

A portion of the facility site is underlain by a bedrock ridge that trends southwest to northeast from the hills to the south. The ridge underlies the eastern portion of the Refinery Area and the western portion of the Tank Farm Area. Alluvial deposits are generally thin over this ridge and become thicker on the flanks. The ridge partially separates the alluvial sequence in the Refinery Area from that in the Tank Farm Area.

In the Refinery Area, the unconsolidated sediments which overly bedrock are generally composed of clay and silty/sandy clay as illustrated in the geologic cross-sections of Figures 2-7 through 2-11. (As mentioned above, the geologic cross-sections were constructed from boring information collected during various investigations prior to the RFI). The southern area is



mainly underlain by clay. The northern area is composed of interbedded lenses of clay, silty/sandy clay, and sand. The sand lenses appear to be limited in areal extent and isolated from each other. Boring logs (presented in Appendix D) and grain size analyses (presented in Appendix H) performed during the RFI show that the surficial sediments to a depth of about 15 ft bgl vary from medium sand to silt and clay. A detailed geologic description based on the boring logs and grain size analyses for each SWMU is presented in Section 5. The depth to bedrock varies from less than 10 ft bgl at Route 901 near the south side of the Refinery Area to over 60 ft bgl at the north side.

In the Tank Farm Area, the surficial geology is composed of sandy clay, clayey sand, and clay. The deeper geology is mainly composed of interbedded lenses of clay, sandy clay, clayey sand, and sand. Beneath the surficial sandy clay is a sand layer ranging in thickness from 5 to 30 feet which trends north-south. This sand layer pinches out to the west and does not extend to beneath the Refinery Area. Underlying the sand layer are interbedded lenses of clay, sandy clay, clayey sand, and sand. A discontinuous clay unit is found at greater depths. The depth to bedrock varies from about 50 ft to over 80 ft.

In the Dock Area, the surficial geology is composed mainly of sand which has a thickness that varies from about 15 to 45 ft. Underlying the sand layer are interbedded lenses of clay, sandy clay, clayey sand, and sand, which is similar to the Tank Farm Area. The depth to bedrock varies from about 80 to 100 ft at the Dock Area.

The geologic cross-sections presented in Figures 2-7 through 2-11 include notes regarding the range of depths to groundwater at the investigation areas. Since the engineering borings used to construct the cross-sections were not converted to monitoring wells, water level data specific to the cross-sections are not available. Also, none of the cross-sections traversed wells installed during the RFI. As discussed in Section 2.9, the depth to groundwater ranged from about 2 to 14 ft below ground level.

## **2.8 Regional Hydrogeology**

Within the alluvial deposits of the Yabucoa basin are deep water-bearing sand strata which compose the main regional aquifer. These sand strata, located mostly within the central part of the valley, are limited in areal extent. Many of the sand strata are apparently elongated lenses oriented parallel to the valley in an east-west direction. The deeper lenses pinch out and do not

extend southward to the margin of the valley where the SCYI facility is located (see geologic cross-section C-C' of Figure 2-9). Cross-section C-C', which traverses several of the facility production wells, also shows their screen depths. A shallow sand lense with a maximum depth of about 35 ft below ground level (bgl) and a thickness varying from about 4 to 35 ft exists beneath the Tank Farm and Dock Areas, but not the Refinery Area (see geologic cross-sections D-D' and E-E' of Figures 2-10 and 2-11, respectively). This shallow sand lense, which may not be continuous to other portions of the valley, does not likely extend to deeper portions of the Yabucoa basin north of Santiago Creek shown in the bedrock map of Figure 2-6.

Based on aquifer tests conducted at facility water supply wells near the center of the Yabucoa valley, the alluvial aquifer has transmissivities ranging from 21,000 to 40,000 gpd/ft. Storage coefficient data indicate that the aquifers are under semi-confined to confined conditions. Rapid response of water levels to rainfall events in the well field area indicate that leakage occurs through confining layers between the shallow water table aquifer and deeper aquifer zones (Geraghty & Miller, 1987). Well yields vary from 300 to over 1000 gpm. The majority of public and industrial water supply for the area is derived from groundwater resources.

SCYI's current water well production field consists of four wells and extends from about 2300 to 7000 ft north to northwest of the Refinery Area. The locations of the four production wells, which are identified as wells PW-1, PW-2, PW-3, and PW-6; are shown in Figure 2-12. Well PW-4, which is also shown on Figure 2-12, is not in use. Former well PW-8 was abandoned during 1988-89. Available construction details for the production wells are presented in Table 2-1. Average pumping rates from the well field have been as follows: 1600 gpm from 1978 to 1980; 1200 gpm from 1980 to 1993; and 800 gpm from 1993 to 1996 (USGS, 1996a). Average pumping rates reported by the facility during 2002, 2003, and 2004 were 515 gpm, 588 gpm, and 558 gpm, respectively.

The general pre-development groundwater flow direction in the Yabucoa valley aquifer system, which is illustrated in Figure 2-13 was from west to east toward the Caribbean Sea with a gradient of about 10 ft/mile.

A 1990 groundwater elevation map for Yabucoa valley alluvial aquifer developed by the USGS is presented in Figure 2-14. The USGS map shows a cone of depression north and northwest of the facility resulting from groundwater pumping, mainly from the SCYI well field. As a result of the pumping, groundwater levels in the well field area have locally declined such that the



groundwater flow direction is radially toward the well field. Several items should be noted about the applicability of this map with respect to the facility area. Firstly, the facility decreased the pumping rate from the well field in 1993, which suggests that the map is no longer representative and that the cone of depression is less extensive than shown on the map. Secondly, the map was made utilizing many wells that tap deeper aquifer zones not present at the facility. The sediment thicknesses significantly thin toward the south side of Yabucoa Valley at which the facility is located. Thirdly, the USGS map apparently utilized only one well (presumably the Old Construction Well) to define the water levels in the facility area. The Old Construction Well (OCW), which is located at the northern border of the refinery area taps a deeper water-bearing zone. Therefore, although the USGS map of Figure 2-14 may be somewhat useful for evaluating regional groundwater conditions, it does not accurately portray conditions at the SCYI facility. Rather, site-specific data discussed in Section 2.9, should be used for evaluating the groundwater elevation and flow direction characteristics at the facility.

Groundwater levels near the center of Yabucoa valley northeast of the refinery area are monitored on a regular basis by the U.S. Geological Survey (USGS) at well TW-2 (also identified as well Yabucoa 7). The location of well TW-2, which is situated in the central part of Yabucoa valley about 7500 ft north-northwest of SCYI Refinery Area, is shown in Figures 2-12 and 2-14. Figure 2-15 shows the long-term water level record between 1993 and 1997 at USGS well TW-2. The water levels at well TW-2 generally follow seasonal patterns with no apparent long-term trend of increasing or decreasing levels. In general, groundwater levels in the Yabucoa area are highest in September during the rainy season and lowest during the dry months of March and April (USGS, 1996b). During a 5-year period from 1993 to 1997, groundwater elevations at well TW-2 fluctuated from about 2 to 9 ft above mean sea level (amsl) with no obvious decreasing trend. This indicates that there is no long-term influence at this location from pumping at the production wells in the central part of the valley. A similar situation likely exists at the SCYI facility, since the distances from the production wells to well TW-2 and from the production wells to the Refinery Area are similar. Also, since the water level record at well TW-2 does not show any long-term trend of declining water level, groundwater recharge to the aquifer appears sufficient to compensate for groundwater extracted for public and industrial supply.

The general vertical groundwater flow direction in the Yabucoa valley appears to be downward from the uppermost water bearing zone to deeper zones based on data supplied by USGS for a series of nested wells located throughout the valley (USGS, Puerto Rico, 1997; personal

communication with Joe Troester). The locations of the nested monitoring wells used by the USGS are shown in Figure 2-16. Groundwater level and well construction data for these monitoring wells presented in Table 2-2 show that the uppermost water-bearing zone had a higher hydraulic head compared to deeper water-bearing zones indicating downward vertical flow.

## **2.9 Site-Specific Hydrogeology**

Site-specific groundwater level, flow and velocity conditions and aquifer characteristics are discussed in this section. A discussion of groundwater and surface water interconnection issues is also presented.

### Groundwater Level and Flow Direction

A groundwater elevation and flow direction maps constructed from synoptic water level measurements collected during the RFI on September 1, 1996 and April 22, 2003 at the SCYI facility are presented in Figures 2-17 and 2-18, respectively. Data used for the construction of the maps is discussed in Section 4.3.1.

Figures 2-17 and 2-18 show that groundwater elevations at the site varied from about 1 ft above mean sea level (amsl) at the Dock Area to over 21 ft amsl in the Refinery Area. The depth to groundwater, which is affected mainly by topographic relief, varied from about 2 to 15 ft below ground level (bgl). The general groundwater flow direction was to the north and northeast within the Refinery Area; to the east and northeast within the Tank Farm Area; and to the east and southeast within the Dock Area. Groundwater exits the Refinery Area generally in a northeast direction.

Historical records for a 5-year period from 1991 to 1996 from groundwater monitoring wells at the equalization basin located in the northeast part of the Refinery Area show a seasonal water level variation of about 5 ft. The seasonal water level changes, which generally followed rainfall cycles, did not significantly affect the groundwater flow direction. The seasonal water level variation decreases in magnitude toward the Caribbean Sea where groundwater elevations are lower.

The production water wells for the facility are the most downgradient water supply wells in Yabucoa valley. They are located north and north-northwest of the Refinery Area; northwest of the Tank Farm area; and generally to the east of the Dock Area. Based on the groundwater flow direction data for the facility, none of the production wells are located downgradient of the site. Therefore, any contamination at the site is unlikely to affect the facility water supply well field or other water supply wells located northeast of the site.

As discussed in Section 2.8, groundwater pumping from the facility water supply wells has resulted in a localized decline in water levels in the well field area northeast of the facility. No apparent effect at the facility from the pumping is observed, however, since the present groundwater flow direction for the facility area (see Figures 2-17 and 2-18) is generally consistent with the regional pre-development and 1990 groundwater flow direction (see Figures 2-13 and 2-14).

Two rounds of groundwater sampling at the OCW have not detected any groundwater contamination in the Northeast Refinery Area. Also, groundwater results at the Northeast Refinery Area discussed in Section 5.9 do not show any contamination above screening levels, which indicates no impact to groundwater irrespective of the groundwater flow direction conditions.

#### Aquifer Characteristics

The uppermost aquifer zone at the facility is unconfined. During the RFI in September 1996, in order to evaluate the hydraulic characteristics of the uppermost aquifer zone, a pumping test was conducted at the Main Dock Sump Area (SWMU 33). Slug tests were also conducted at the Barge Dock Sump Area (SWMU 34) and at the Northeast Refinery Area. The pumping test used well MDS-3 as the pumping well; well MDS-4 and an existing large diameter well were used as observation wells. The test was run for a 12-hour period followed by a 12-hour recovery period. Water level measurements were collected at well MDS-8 for tidal corrections. A large-scale figure showing the location of the wells is presented in Figure 5-26. Results from the pumping and slug tests, which are presented in Appendix C, are summarized below.

<u>Area</u>	<u>Hydraulic Conductivity (ft/day)</u>
Northeast Refinery Area (well 40-09)	0.4 and 1.2
Barge Dock Sump Area (wells BDS-1 and BDS-6)	greater than 50
Main Dock Sump Area (well MDS-3)	250

The hydraulic conductivity value for the Main Dock Sump Area (SWMU 33) was determined using an effective saturated thickness of 13 ft and a transmissivity value from the pumping test of about 24,500 gpd/ft (3270 ft<sup>2</sup>/day).

The data indicate that hydraulic conductivity generally increases from the Refinery Area toward the Caribbean Sea. This is consistent with the information presented in the geologic cross sections discussed in Section 2.7, which indicates that more permeable sandy aquifer zones are more predominant in the Tank Farm and Dock Areas. Less permeable silty and clayey water-bearing zones predominate in the Refinery Area.

Results from previous short-term aquifer tests in 1985 indicate aquifer transmissivity values ranging from 490 to 560 gpd/ft at the Refinery Area and from 1,000 to 6,000 gpd/ft in Tank Farm Area (Geraghty & Miller, 1985). These transmissivities are significantly lower than those measured at the Dock area and also in the central part of the valley as discussed in Section 2.8.

#### Groundwater Velocity

The groundwater gradient at the Refinery Area determined from the groundwater level map of Figure 2-17 is about 20 ft/mile which is two times greater than that at the central part of Yabucoa valley (see Section 3.7). The higher gradient at the side of the valley is attributed to lower aquifer transmissivity. At the Dock Area, which is near the centerline of the valley, the gradient is estimated to be about 5 ft/mile. Average horizontal groundwater velocities were calculated to be about 0.01 ft/day in the Refinery Area, 0.07 ft/day in the Tank Farm Area, and 0.8 ft/day in the Dock Area. The calculations were made using Darcy's Law, the hydraulic characteristics discussed above, and an effective porosity of 0.3.

### Vertical Groundwater Flow Direction

The vertical groundwater flow direction appears to change seasonally at the Northeast Refinery Area. Groundwater level data from September 1996 indicated a downward flow direction while data from January 1997 indicated an upward flow direction. The vertical gradient was also upward in April 2003, downward in May 2003, and then upward in June 2003. The vertical gradient in the Tank Farm area at the East API Separator and Watery Oil Separator was downward in April and June 2003. A detailed discussion for the determination of the vertical gradient is presented in Section 4.3.2.

Boring logs presented in Appendix D for the RFI wells at the Northeast Refinery Area indicate that the geology near the water table is generally a sandy clay. Geologic cross-section C-C' presented in Figure 2-9 shows that the underlying geology in the area consists of a clay unit. Although the vertical groundwater flow direction at the Northeast Refinery Area may be downward during certain seasons, the low vertical hydraulic conductivity of the underlying clay inhibits the vertical movement of any contamination from shallow to deep levels. Additionally, as discussed in Sections 5.9, petroleum hydrocarbon contamination detected near the water table in the Northeast Refinery Area has not impacted deeper water-bearing zones. As discussed in Sections 5.11 and 5.12 for the East API Separator (SWMU 3) and Watery Oil Separator (SWMU 43), petroleum hydrocarbons have also not impacted deeper water-bearing zones.

USGS regional data cited in Section 2.8 suggest a downward flow direction from the uppermost to deeper water-bearing zones in upvalley areas. Groundwater discharge to the Caribbean Sea with a corresponding upward flow direction is likely in areas closer to the Sea such as at the Tank Farm and Dock Areas. The site-specific groundwater elevation and flow direction maps for the uppermost aquifer of Figures 2-17 and 2-18 indicates groundwater discharge to the Caribbean Sea with a corresponding upward flow direction.

### Groundwater and Surface Water Interconnection

The interconnection between the groundwater at the Northeast Refinery Area (SWMU 40) and the surface water of the bordering Santiago and Lajas Creeks was evaluated as part the RFI. Two sets of staff gauges were installed in the creeks for the evaluation. The locations of staff gauges are shown in Figure 2-19 along with the locations of nearby monitoring wells. The first set of staff gauges was installed during 1996 for the initial RFI work. Since the gauges were



destroyed during storm activity, a second set of staff gauges was installed during 2003 for the Supplemental RFI work. Each set of staff gauges were surveyed to the nearest 0.01 ft. Surface water level measurements were performed at the first set of gauges on September 20, 1996 and January 28, 1997, and quarterly at the second set of gauges during June 2003 through June 2004. Synoptic water level measurements at nearby monitoring wells were also collected. The relationship between surface water and groundwater interconnection was determined by comparing surface water levels at the various staff gauges with groundwater levels at nearby water-table monitoring wells.

During the RFI in 1996, three staff gauges (SG-1, SG-2, and SG-3) were installed in Santiago Creek and one gauge (SG-4) was installed in Lajas Creek (reference Figure 2-19 for locations). Synoptic water levels at the staff gauges and groundwater levels at nearby monitoring wells were measured on September 20, 1996 and January 28, 1997. Tables 2-3 and 2-4 present the respective groundwater level data at the monitoring wells; Table 2-5 presents the corresponding surface water level data at the staff gauges (levels at staff gauge SG-3 were not available as the gauge was destroyed during a storm).

Santiago Creek surface water levels at staff gauge SG-2, as presented in Table 2-5, were compared to groundwater levels at nearby monitoring well 40-15, as presented in Tables 2-3 and 2-4. On September 20, 1996, the surface water level at staff gauge SG-2 (11.46 ft amsl) was higher than the groundwater level at well 40-15 (11.18 ft amsl) indicating surface water recharge from Santiago Creek to the adjacent groundwater. On January 28, 1997, the surface water level at staff gauge SG-2 (9.71 ft amsl) was slightly lower than the groundwater level at well 40-15 (9.76 ft amsl) indicating groundwater discharge to Santiago Creek.

Lajas Creek staff gauge SG-4 was located opposite the midpoint between nearby monitoring wells 40-10 and 40-12. The general groundwater flow direction in the area is to the northeast as shown in Figures 2-17 and 2-18. Therefore, surface water levels at staff gauge SG-4 in Lajas Creek were compared to the estimated groundwater levels at the midpoint between adjacent monitoring wells 40-10 and 40-12. The midpoint water level was determined by interpolation between the wells (the median water level). On September 20, 1996 the groundwater level at the midpoint between wells 40-10 and 40-12 (11.73 ft amsl) was higher than surface water level at staff gauge SG-4 (10.98 ft amsl) indicating groundwater discharge to Lajas Creek. On January 28, 1997 the groundwater level at the midpoint between wells 40-10 and 40-12 (9.76 ft amsl) was also higher than surface water level at staff gauge SG-4 (8.44 ft amsl), again indicating

groundwater discharge to Lajas Creek. the groundwater levels at the well 40-10/40-12 midpoint were higher than surface water levels at staff gauge SG-4 indicating groundwater discharge to Lajas Creek.

As part of the Supplemental RFI work during 2003, two staff gauges (SC-1 and SC-2) were installed in Santiago Creek and two staff gauges (LC-1 and LC-2) were installed in Lajas Creek (reference Figure 2-19 for locations). Surface water levels at the gauges and water levels in nearby groundwater wells were measured quarterly between June 2003 and June 2004. The surface water level at staff gauge LC-1 and nearby monitoring well 40-11 were additionally measured in July 2004.

For Lajas Creek, surface water levels at staff gauge LC-1 were compared with the groundwater levels at nearby well 40-11. Also, surface water levels at staff gauge LC-2 were compared with groundwater levels at nearby well 40-12.

For Santiago Creek, surface water levels at staff gauge SC-1 were compared with the groundwater levels at nearby well 40-15. Also, surface water levels at staff gauge SC-2 were compared with the groundwater levels at nearby well 40-14A.

Table 2-6 presents the surface water and groundwater level measurement data from the five quarterly synoptic during the Supplemental RFI monitoring period between June 2003 and June 2004, and the additional measurement in July 2004 at staff gauge LC-1 in Lajas Creek. The data indicate surface water recharge from Santiago Creek, with reversals during two quarters in the area of gauge SC-1. The data also indicate groundwater discharge to Lajas Creek, with a minor reversal during one quarter in the area of gauge LC-1.

Overall, the results of the 1996-97 and 2003-2004 surface water and groundwater level measurements show that the surface water from Santiago Creek recharges the groundwater and that groundwater discharges to Lajas Creek. Occasional flow direction reversals occur mainly at the area of gauges SG-2 and SC-1 in Santiago Creek.

Stream discharge measurements at three locations along Santiago Creek made by the USGS (USGS, 1996a) also suggest that the surface water from Santiago Creek is recharging the groundwater nearby the SCYI facility. However, discharge measurements at a fourth location

about one mile upstream of the SCYI facility suggests that groundwater is discharging to the upstream reach of the Creek.

## 2.10 Tidal Influence

A chart showing the monthly range of ocean tidal fluctuations at Roosevelt Roads Air Station, which is about 19 miles northeast of the SCYI facility, is presented in Figure 2-20. The chart, which illustrates tidal fluctuations for July 1996, shows a monthly tidal maximum range of 1.6 ft. The average diurnal range was 1.0 ft.

During the RFI, groundwater levels were recorded for a 4 to 7 day period using an electronic data logger at three wells near the inlet from the Caribbean Sea. The purpose was to determine tidal affects on groundwater level and flow. Figure 2-21 shows the location of the wells which are identified as wells DA-1 and BDS-1 in the Barge Dock Sump (SWMU 34) area and well MDS-8 in the Main Dock Sump (SWMU 33) area.

Graphs showing tidal groundwater fluctuations at wells MDS-8, BDS-1, and DA-1 are presented in Figures 2-22, 2-23, and 2-24, respectively. Tidal fluctuations at the wells and their distances from the inlet from the Caribbean Sea are summarized below.

<u>Well</u>	<u>Distance from inlet (ft)</u>	<u>Tidal Fluctuation (ft)</u>
MDS-8	20	0.1
BDS-1	25	0.2
DA-1	750	0.01

The data show that tidal effects are diminished significantly at a distance of 750 ft from the Turning Basin. The data also indicate that the groundwater flow direction is unaffected by tidal fluctuations at this distance. Assuming the tidal fluctuations occur nearly synoptically at wells in close proximity to the Turning Basin such as at the Main Dock Sump (SWMU 33) and Barge Dock Sump (SWMU 34), groundwater flow direction at the units is not significantly affected by tidal fluctuations. Therefore, tidal effects are not likely to cause a reversal of groundwater flow direction that would allow any dissolved contamination from the SWMUs at the Dock Area to affect the drinking water supply wells located within the Yabucoa valley. Additionally, the site-



specific groundwater elevation and flow direction maps of Figures 2-17 and 2-18 indicates the groundwater flow direction is eastward toward the Caribbean Sea.

### **3.0 Field Investigation Procedures**

This section describes the soil sampling, monitoring well installation, and groundwater sampling procedures utilized for the RFI field work. The analytical methods and quality assurance/quality control (QA/QC) procedures used for the soil and groundwater sampling work are also described. All field investigation procedures and sampling and analysis protocols were consistent with those contained in the approved RFI Work Plan.

#### **3.1 Soil Sampling Procedures**

Soil sampling during the 1996 phase of the RFI was performed using split-spoon sampling. The split-spoons were advanced into the subsurface using either a hollow-stem auger drill rig or a tripod rig depending on site access. The hollow-stem auger (HSA) rig was used in accessible areas and the tripod rig was used in areas with limited access. Continuous soil sampling was performed at the sampling locations using 2-ft split-spoon cores. The split-spoons (1.5-in inside diameter) were driven into the ground using the HSA and tripod rigs using a 140-lb hammer with a 30-inch drop. The HSA borings were advanced using the HSA; the split-spoon sampling was then performed through the inside of the auger. The tripod borings were advanced using the split-spoon sampler. The cores were screened visually for staining and also with a photoionization detector (PID). Split-spoon blow counts were recorded to indicate soil conditions. The site geologist also described the soil type and characteristics of the split-spoon cores.

Soil sampling during the 2003 Supplemental RFI was performed using the direct-push soil sampling method. Continuous soil sampling was performed at the sampling locations using 4-ft cores. The cores were screened visually for staining and also with a photoionization detector (PID). The site geologist also described the soil type and characteristics of the split-spoon cores.

All drilling, augering, and sampling equipment was decontaminated before use. The drilling equipment, including rig, augers, etc. was steam cleaned in a designated areas with a pressurized steam cleaner. The split-spoon and direct-push downhole coring equipment was decontaminated between sampling locations using a sequence of tap water/non-phosphate detergent scrub, tap water rinse, isopropanol (pesticide grade) rinse, 10% ultrapure nitric acid rinse, analyte-free water rinse, and air dry.

### 3.2 Monitoring Well Installation Procedures

During the 1996 RFI work, a total of 48 groundwater monitoring wells were installed. Three of these wells were installed as permanent wells. The remainder were installed as temporary groundwater monitoring wells. An additional 10 permanent wells were installed as part of Supplemental RFI work during 2003 to 2005.

The term “temporary well” was used primarily as an administrative description to indicate that the well was installed additional to the scope of the RFI Work Plan and that it might be decommissioned within a short time period after installation. (The existing “temporary wells” will not be decommissioned unless agreed beforehand with EPA). Due to the usefulness of these “temporary wells” for interim measures monitoring, the facility proactively kept them in place. The temporary wells were constructed inside a hollow-stem auger (or within the split-spoon boring where access was limited to a tripod rig) using PVC casing and screen, a sand pack, and a bentonite seal. The main difference between a “temporary well” and a “permanent well” was that clean fill, instead of grout, was typically used to seal the borehole annulus above the bentonite seal and sand pack. This difference did not compromise the strength of the wells or diminish the quality of the groundwater data obtained from them, nor will it result in a significant decrease in the useful lifetime of the wells. At some locations, the annulus above the bentonite seal was sealed with grouted instead of with clean fill, making them equivalent to permanent wells. Additional details concerning the construction of the temporary wells are provided on the boring logs included in Appendix D.

The Work Plan specified collecting groundwater samples with a Geoprobe/Hydropunch. This would have involved driving a groundwater sampling probe to a specified level, collecting a groundwater sample, and then retracting the sampling probe. Its use is limited to collection of a discrete groundwater sample for a single sampling event. Temporary wells discussed above were employed for collection of the groundwater samples specified in the Work Plan and to achieve additional goals which could not be obtained with the Geoprobe/Hydropunch. The additional goals were as follows:

- Groundwater level observations
- Collection of additional groundwater samples in the future, if needed, without remobilizing a drill rig
- Free product delineation and thickness measurements

- Free product recovery, if needed

During the Supplemental RFI work between 2003 and 2005, monitoring wells were installed using a hollow-stem auger system with the exception of well 03-11 at the East API Separator, which is discussed below. At each well, an 8-inch outside diameter (OD) well boring was advanced to the total depth using the auger. The well casing and screen were installed through the hollow-stem of the auger. The auger flights were removed one by one as various components of the well were built. The screen and casing string for the wells consisted of a 10-ft length of 2-inch diameter, schedule 40 PVC screen (20-slot) installed near the bottom of the auger boring. The screen was connected to a 2-inch PVC casing installed to above ground level. A sand pack was installed opposite the screen to a depth of about 2 to 3 ft above the top of the screen. A bentonite seal about two ft thick was installed above the sand pack. The borehole annulus was then grouted to the ground surface. A protective steel surface casing with a locking cap was installed at the top of the well.

Well 03-11 at the East API Separator was installed beneath a piperack east of the unit. The well was installed using hand-operated direct-push equipment since access by hollow-stem auger or tripod drilling equipment was not possible. A 2-inch OD boring was advanced to a depth of about 11 ft below ground level (bgl). The screen and casing string for the wells consisted of a 7-ft length of 1-inch diameter, schedule 40 PVC screen (20-slot) installed at the bottom of the boring. The screen was connected to a 1-inch PVC casing installed to above ground level. A sand pack was installed opposite the screen to a depth of several inches above the top of the screen. A one-ft thick bentonite seal was installed above the sand pack. The borehole annulus was then grouted to the ground surface. A protective steel surface casing with a locking cap was installed at the top of the well.

Well construction details for the wells installed during the 1996 RFI work and 2003 Supplemental RFI work are presented in Table 4-1 of Section 4.

As part of well installation, continuous soil sampling by split-spoon or direct-push was performed at the well locations. The continuous soil samples were screened for quality observations using visual observations and by measuring the headspace of the soil samples with a PID. Step-out borings were not necessary since none of the screening results or subsequent well observations indicated the presence of FPH. The soil samples were described by AMAI's on-site geologist. Geologic logs from the well borings are presented in Appendix D.

The wells were developed by bailing and/or with a centrifugal pump until the purge water was clean or a maximum of about ten well volumes. After development, the wells were allowed to stabilize for a period of at least two weeks prior to performing groundwater sampling activities, FPH observations, and groundwater level measurements.

The elevations of wells were measured to the nearest 0.01 ft by a licenced surveyor. Additionally, a number of existing wells at the facility that needed elevations were surveyed to assist with groundwater elevation and flow direction determinations. The surveyor's report is included in Appendix B.

### **3.3 Groundwater Sampling Procedures**

The groundwater sampling method used for the 1996-1997 RFI work was as specified in the approved RFI Work Plan. Three to five well volumes were initially purged from the wells. Purging was performed with a Teflon bailer or centrifugal pump with polyethylene hose and foot valve. After purging, the water level was allowed to recover to at least 80 percent of the initial water column in the well, or prior to three hours if full recovery was not possible due to low formation yield. The well was then sampled with a Teflon bailer by slowly lowering it into the well. Groundwater samples for VOCs were collected first, followed by BNAs and dissolved metals. Samples for dissolved metals were field filtered using a 0.45 micron filter. Immediately after sample collection, the sample containers were placed in ice-filled coolers for transport to the lab for analysis.

During the 2003 Supplemental RFI work, groundwater sampling activities were performed according to EPA low-flow guidance (EPA Region II, 1998; and EPA, 2002). The general groundwater sampling procedure was as follows: a PID reading of the headspace was taken upon opening a well; the water level and well depth were measured; the well was purged using low-flow procedures; and the well was sampled using low-flow procedures.

If headspace measurements indicated potential FPH in a well, or if previous FPH thickness measurements at a well suggested potential FPH, its thickness was measured using an electronic interface probe prior to well purging. Groundwater sampling was not performed at any well that had a measurable FPH thickness greater than a sheen. Only well MDS-4 had a measurable FPH thickness (0.06 ft on April 2, 2003), which occurred during the April 2003 sampling event, therefore, the well was not sampled at that time. The source of the FPH at well MDS-4 was due

to a pipeline release incident that occurred on January 31, 2002, and subsequently reported to EPA. However, since FPH measurements at the well in June 2003 indicated only a sheen, it was sampled at that time. The sheen at well MDS-4 was removed with an absorbent pad prior to sampling. Wells 40-11, 40-12, 40-21, and BDS-2 also had sheens, which were removed with absorbent pads prior to sampling.

During the 2003 Supplemental RFI work, the wells were sampled after the groundwater indicator parameters (specific conductivity, pH, dissolved oxygen, and redox) of the purge water stabilized to the criteria specified in the EPA guidance for three consecutive measurements taken 5 minutes apart. Samples for VOCs were collected first, followed sequentially by samples for BNAs, total metals, and dissolved metals. The dissolved metal samples were filtered in the field using a 0.45 micron filter. The groundwater samples were collected in bottles containing preservatives supplied by the laboratory. Samples for VOCs and metals were preserved to a pH of less than 2 using hydrochloric acid and nitric acid, respectively, and then placed on ice. BNAs were also preserved on ice. After sample collection, the sample bottles were stored on ice for shipment to the lab.

Well purging and sampling were performed using bladder pumps with the exception of well 3-10A at the East API Separator. At well 3-10A, a peristaltic pump was used for purging and sampling due to the small water column in the well. Dedicated Teflon-lined polyethylene purging/sampling tubing was used at all sampling locations. The bladder pumps were decontaminated between sampling locations using the following sequence: tap water/non-phosphate detergent scrub, tap water rinse, isopropanol (pesticide grade) rinse, 10% ultrapure nitric acid rinse, analyte-free water rinse, air dry, and aluminum foil wrap.

### **3.4 Analytical Methods and Quality Assurance/Quality Control**

During the 1996-1977 RFI work, groundwater and soil samples were analyzed for Target Compound List (TCL) VOCs and BNAs, and/or Modified Skinner List (MSL) metals using Contract Laboratory Program (CLP) methods.

During the 2003 Supplemental RFI work, groundwater samples were analyzed for Target Compound List (TCL) VOCs and BNAs, Modified Skinner List (MSL) metals, antimony, arsenic, and/or lead using the following analytical methods:



- VOCs by low-level CLP methods, with the exception of the sample from well 03-10A. (The groundwater sample from well 03-10A was inadvertently analyzed using SW-846 Method 8270B. However, the accuracy and results of this method are comparable to CLP methods).
- BNAs by SW-846 Method 8270C
- Metals (total and dissolved) by CLP

During the 2003 Supplemental RFI work, soil samples were analyzed for TCL VOCs and BNAs, and/or MSL metals using the following analytical methods:

- VOCs by SW-846 Method 8260B
- BNAs by SW-846 Method 8270C
- Metals by CLP

During the 2003 Supplemental RFI work, surface water samples were analyzed for TCL VOCs, BNAs, and/or MSL metals using SW-846 Method 8260B, SW-846 Method 8270C, and CLP methods, respectively. Sediment samples were analyzed for VOCs and polycyclic aromatic hydrocarbons (PAHs) using SW-846 Method 8260B and SW-846 Method 8270C-SIM, respectively. The 8270C-SIM (selective ion monitoring) method for PAHs allows for lower detection limits of selected constituents.

QA/QC samples were collected according to the Quality Assurance Project Plan (QAPP) of the approved RFI Work Plan. Groundwater QA/QC samples consisted of equipment blanks and duplicates. Additionally, a trip blank accompanied each sampling cooler containing VOCs. Soil QA/QC samples consisted of equipment blanks and duplicates. The sampling frequency was one of each type of QA/QC sample per twenty program samples for groundwater and the same for soil. A temperature blank was included in each sample cooler; its temperature was recorded by the lab upon receipt.

The groundwater and soil QA/QC equipment blank and duplicate samples were analyzed for the same constituents (VOCs, BNAs, and metals) as the program samples. The groundwater sampling trip blanks were analyzed for VOCs only.

Laboratory analyses for the 1996-1997 RFI work were performed by Core Laboratories, Inc. of Edison, New Jersey. The data were validated using EPA Region II functional guidelines by



Dataval, Inc. of Endwell, New York. Laboratory analyses for the 2003 Supplemental RFI work were performed by Accutest Laboratories, Inc. of Dayton, New Jersey. The data were validated by Premier Environmental Inc., of Merrick, NY and Rafael Infante, a certified chemist in Puerto Rico. The data validation/certification reports are presented in Appendix J.

## **4.0 Groundwater Flow and Vertical Gradient Evaluation**

This section presents a description of the activities and results of the groundwater flow and vertical gradient evaluation performed for the RFI.

### **4.1 Objective**

The objectives of groundwater flow and vertical gradient evaluation were as follows:

- Provide sitewide data concerning the groundwater elevation and flow direction in the facility area.
- Provide data concerning the groundwater vertical hydraulic gradient at three locations in the Refinery and Tank Farm Areas.

### **4.2 Scope**

Groundwater levels were measured on September 1, 1996 and April 22, 2003, at new and existing facility-wide monitoring wells for evaluation of the groundwater flow direction. Seventy wells were measured for the September 1996 measuring event; 28 of these wells were located in the Refinery Area, 23 wells in the Tank Farm Area, and 19 wells in the Dock Area. Eighty-two wells were measured for the April 2003 measuring event; 30 of these wells were located in the Refinery Area, 31 wells in the Tank Farm Area, and 21 wells in the Dock Area. A large scale map showing the locations of the groundwater level monitoring wells is presented in Plate 2. The water levels were measured at the wells to the nearest 0.01 ft using an electronic water level meter. Construction details of new wells installed during the RFI are presented in Table 4-1. Available construction details of existing groundwater monitoring wells installed for general environmental purposes prior to the RFI that were used for the groundwater level measurements are presented in Table 4-2.

During the initial RFI work, vertical gradient measurements were made using the deep Old Construction Well in the Northeast Refinery Area (SWMU 40) and nearby shallow monitoring wells. Measurements were made in September 1996 and January 1997. The location of the OCW and other wells in the Northeast Refinery Area are shown in Figure 2-19.

During the Supplemental RFI work, vertical gradient measurements were made at three well clusters: one cluster in the Refinery Area and two in the Tank Farm Area. The locations of the well clusters are shown in Figures 2-19, 5-16, 5-19, and Plate 2. The well cluster in the Refinery Area consists of shallow well 40-14A and deep well 40-14B in the Northeast Refinery Area. Well clusters in the Tank Farm Area are located at the East API Separator (SWMU 3) and Watery Oil Separator (SWMU 43). The cluster at the East API Separator consists of shallow well 03-10A and deep well 03-10B. The cluster at the Watery Oil Separator (SWMU 43) consists of shallow and deep wells WOS-4A and WOS-4B, respectively. Wells 40-14A and 03-10A were installed in July 1996 as part of the initial phase of the RFI. Wells 40-14B, 03-10B, and WOS-4A and WOS-4B were installed in February 2003 as part of the Supplemental RFI. Well construction methods are discussed in Section 3.2. Well construction details are summarized in Table 4-1.

Details concerning the relationship of the well cluster screen depths for determination of the vertical gradient are as follows:

- Well 40-14B at the Refinery Area was screened from 28.3 to 38.3 ft bgl, which intercepts a sand zone overlying a silty clay. The upper part of the screen is set opposite the sand zone and the base of the well is set within the clay. Deep well 40-14B was installed 5.5 ft east of shallow well 40-14A. Shallow well 40-14A, which was installed during RFI work in 1996, is screened near the top of the water table. The vertical distance between the midpoint of the screens for wells 40-14A and 40-14B is 20.8 ft.
- Well 3-10B at the East API Separator (SWMU 3) of the Tank Farm Area was screened from 25.1 to 35.1 ft bgl, which intercepts a sand zone overlying a sandy silty clay. The upper part of the screen is set opposite the sand zone and the base of the well is set within the clay. Deep well 3-10B was installed 7 ft east of shallow well 3-10A. Shallow well 3-10A, which was installed during RFI work in 1996, is screened near the top of the water table. The vertical distance between the midpoint of the screens for wells 3-10A and 3-10B is 21.5 ft.
- Well WOS-4B at the Watery Oil Separator (SWMU 43) of the Tank Farm Area was screened from 26.3 to 36.3 ft bgl, which intercepts a sand zone overlying a gravelly, sandy, silty clay. The upper part of the screen is set opposite the sand zone. The bottom

of the screen is about 1 ft above the clay. Deep well WOS-4B was installed 4 ft south of shallow well WOS-4A. Shallow well WOS-4A, which was installed during the Supplemental RFI work in February 2003, is screened across the water table. The vertical distance between the midpoint of the screens for wells WOS-4A and WOS-4B is 21.0 ft.

For vertical gradient purposes, water levels were measured synoptically at the three well clusters in the Refinery and Tank Farm areas on April 22 and May 8, 2003. Quarterly measurements were also made at the clusters between June 2003 and December 2004.

The elevations of wells were measured to the nearest 0.01 ft by a licensed surveyor. The surveyor's report is included in Appendix B.

## **4.3 Results**

### **4.3.1 Groundwater Level and Flow Direction**

The synoptic groundwater elevations for the September 1, 1996 sitewide groundwater monitoring are presented in Table 4-3. The groundwater elevation and flow direction map constructed from the water elevation data is shown in Figure 2-17.

The synoptic groundwater elevations for the April 22, 2003 sitewide groundwater monitoring are presented in Table 4-4. The groundwater elevation and flow direction map constructed from the water elevation data is shown in Figure 2-18. The data show that groundwater elevations at the facility varied from less than 1 ft above mean sea level (amsl) at the Dock Area to over 21 ft amsl in the Refinery Area. The general flow direction was to the north and northeast in the Refinery Area, to the east and northeast in the Tank Farm Area, and to the east and south in the Dock Area. The groundwater flow direction in the Refinery Area was generally toward the central part of Yabucoa Valley. The groundwater flow direction in the Tank Farm and Dock Areas was generally toward the Caribbean Sea. The groundwater flow direction during April 22, 2003 was generally consistent with that determined during September 1, 1996 indicating that large seasonal variations do not occur.

### 4.3.2 Vertical Gradient

Water level measurements for determining the vertical hydraulic gradient at the Northeast Refinery Area and Tank Farm area were performed during RFI at several nested wells. The results show that the groundwater vertical hydraulic gradient at the Northeast Refinery Area varies seasonally between upward and downward. In the Tank Farm Area, the vertical gradient is downward at the East API Separator (SWMU 3); at the Watery Oil Separator (SWMU 43) the gradient varies seasonally between upward and downward. Details are provided below.

Groundwater level data at the Northeast Refinery Area from September 1996 indicated a downward flow direction while data from January 1997 indicated an upward flow direction. Tables 2-3 and 2-4 present the groundwater level data used for the September 1996 and January 1997 vertical gradient evaluation at the Northeast Refinery Area. The vertical flow observations were made by comparing the water level at the Old Construction Well, which is screened from about 32 to 90 ft bgl, with water levels from nearby wells installed during the RFI which are screened near the water table. In September 1996, the RFI wells indicated a water level about 0.4 ft higher than at the Old Construction Well suggesting a downward flow direction. In January 1997, the RFI wells indicated a water level about 0.3 ft lower than at the Old Construction Well suggesting an upward flow direction. Rainfall amounts were large during August and September 1996 due to tropical storm activity which may have anomalously affected the water level measurements at that time.

Table 4-5 presents the results for the Supplemental RFI vertical gradient evaluation at the Northeast Refinery Area and Tank Farm Area. The vertical gradient results for the Northeast Refinery Area (SWMU 40) show that between April 2003 and December 2004 the vertical gradient varied seasonally between upward and downward, although the upward direction occurred more frequently. The vertical water level differences between the nested wells (40-14A and 40-14B) varied from 0.81 ft in April 2003 to -1.07 ft in May 2003. Since the vertical distance between the midpoint of the well screens is 20.8 ft, the estimated vertical hydraulic gradient varies from 0.039 to -0.051 ft/ft.

The vertical gradient results presented in Table 4-5 for the East API Separator (SWMU 3) show a downward direction during all quarterly measurements between April 2003 and December 2004. The vertical water level differences between nested wells (03-10A and 03-10B) at the East API

Separator varied between -1.86 ft and -3.59 ft. Since the vertical distance between the midpoint of the well screens is 21.5 ft, the estimated vertical hydraulic gradient varied from -0.087 to -0.167 ft/ft.

The vertical gradient results presented in Table 4-5 for the Watery Oil Separator (SWMU 43) between April 2003 and December 2004 show a seasonal variation between an upward and downward direction, although the downward direction occurred more frequently. The vertical water level differences between nested wells (WOS-4A and WOS-4B) at the Watery Oil Separator varied between -0.09 ft and 0.16 ft. Since the vertical distance between the midpoint of the well screens is 21.0 ft, the estimated vertical hydraulic gradient varied from -0.004 to 0.008 ft/ft.

## **5.0 Field Investigation Program and Results**

This section provides a description of the field investigation work performed and the results for each SWMU at the SCYI facility. Section 5.1 provides an introduction to the section including a summary of the scope of the investigation and a discussion on the selection of risk-based screening levels (RBSLs) used for evaluating soil sampling results and screening levels used for evaluating groundwater sampling results. Tentatively identified compounds (TICs) are also discussed in Section 5.1. Section 5.2 provides a description of the soil and groundwater background investigation. Results of the RFI are presented for each SWMU in Sections 5.3 through 5.17. For each SWMU, a description of the scope of the investigation, SWMU-specific geology and hydrogeology, sampling results, and conclusions are provided. Section 5.18 provides an evaluation of the data quality.

### **5.1 Introduction**

#### **5.1.1 Field Investigation Program Overview**

All field activities were conducted in accordance with the procedures set forth in the RFI Work Plan and the Supplemental RFI Work Plan. The objective of the investigation was to characterize the nature and extent of any contamination of surface and subsurface soil or groundwater that may have resulted from releases of hazardous constituents from the sixteen SWMUs subject to the investigation. The field program for soil evaluation utilized a combination of detailed chemical analysis and field screening to define the nature and extent of contamination. Field screening was done for BTEX (benzene, toluene, ethylbenzene, xylenes) and PAHs (polycyclic aromatic hydrocarbons) using immunoassay analytical methods. Field screening permitted on-site analysis for selected classes of constituents and was used to focus field investigations. Full chemical analysis included Target Compound List (TCL) volatile organic compounds (VOCs), base/neutral acid extractable compounds (BNAs), and Modified Skinner List (MSL) metals. Selected soil samples were analyzed for physiochemical properties, including grain size analysis, soil moisture, soil pH, cation exchange capacity, and total organic carbon.



The initial field investigation was conducted between May and September 1996. Confirmatory groundwater samples were collected at certain SWMUs in January and February, 1997. Supplemental investigation activities were conducted between January and June 2003. A total of 91 soil samples were collected for VOC, BNA and/or metals analysis. Eight soil samples were collected for physiochemical analysis. A total of 146 soil samples were collected for field screening by immunoassay. The soil samples were collected from various depths at 68 locations.

A total of 58 groundwater monitoring wells were installed. The wells were used for groundwater level observations, collection of groundwater samples, and/or free-phase hydrocarbon (FPH) delineation and thickness measurements.

As discussed in the respective work plans, the selection of soil and groundwater sampling locations was biased toward areas of suspected contamination at the facility. Although minor deviations to the work plan occurred as a result of unexpected field and hydrogeologic conditions, work plans were substantively completed as proposed. The total number of samples collected during the RFI for analysis exceeded the number of samples specified in the work plan. The locations of the sixteen SWMUs investigated under the RFI are shown in Figure 5-1. SWMU numbers, names and locations are presented in the table below. Eight of the 16 SWMUs are located in the Refinery Area, six SWMUs are located in the Tank Farm Area, and two SWMUs are located in the Dock Area.

SWMU Number	SWMU Name
<i>Refinery Area</i>	
14	Final Retention Basin
17	North Aeration Basin
18	South Aeration Basin
35	Slop Tank 103
36	Dissolved Air Flotation Unit
38	Dewatering Chamber
39	Hazardous Waste Mixing Box
40	Northeast Refinery Area
<i>Tank Farm Area</i>	

SWMU Number	SWMU Name
2	West API Separator
3	East API Separator
43	Watery Oil Separator
44	Ballast Basin Skimmer Area
44A	Ballast Basin Leachate Collection Tank
45	East Aisle Ditch
<i>Dock Area</i>	
33	Main Dock Sump
34	Barge Dock Sump

### 5.1.2 Soil and Groundwater Screening Levels

Analytical results from the RFI soil sampling program were compared to appropriate screening levels to characterize the soil and/or groundwater quality at each SWMU. Soil quality was evaluated using risk-based screening levels (RBSLs) for direct contact exposure pathways (ingestion, dermal, and inhalation of volatile/particulates in outdoor air), and for the migration to groundwater exposure pathway. Groundwater quality was evaluated for the ingestion exposure pathway.

Screening levels do not necessarily represent cleanup standards and alone do not trigger the need for response actions or define unacceptable levels of contaminants in soil or groundwater. Rather the purpose of screening levels is to identify and define areas of contamination that do not require further attention or delineation.

#### Soil

RBSLs for direct contact with soil were obtained from EPA Region 9 preliminary remediation goals (PRGs) for the industrial on-site worker exposure scenario (EPA, Region 9, October 2004). PRGs combines current human health toxicity values with standard exposure factors for the ingestion, dermal and outdoor air exposure pathways into a single screening value.

In general, PRGs for soil are risk-based, although there are two exceptions. The first is that for several volatile chemicals, PRGs are capped at the non-risk based soil saturation concentration (Csat). The Csat corresponds to the level at which non-aqueous phase liquid (NAPL) begins to form. Secondly, for relatively less toxic inorganic and semivolatile contaminants, PRGs are capped at a non-risk based "ceiling limit" concentration of  $10^8$  ug/kg. Constituents with screening levels set at the Csat or ceiling limit are discussed below.

Explanations of direct-contact industrial soil RBSLs for certain specific constituents are as follows:

- The RFI soil data for VOCs report total 1,2-dichloroethene. PRGs are available for both cis- and trans-1,2-dichloroethene. The lower of the PRGs, which was for cis-1,2-dichloroethene, was used for the RBSL for total 1,2-dichloroethene. It should be noted that 1,2-dichloroethene was not detected in any of the soil samples.
- The RFI soil data for VOCs report both cis- and trans-1,3-dichloropropene. A PRG is available for only 1,3-dichloropropane, which was used for the RBSL for both cis- and trans-1,3-dichloropropane. Neither of these compounds were detected in any of the soil samples, however.
- The PRG for total chromium of 450 mg/kg, which is derived using the inhalation cancer slope factor of 42 mg/kg-day as presented in EPA's Integrated Risk Information System (IRIS), was used for the chromium RBSL.
- The PRG for lead of 800 mg/kg was used for the RBSL. This value was derived by EPA Region 9 using EPA's Adult Lead Model.
- The EPA Region 9 PRG for mercuric compounds of 310 mg/kg was used for the mercury RBSL, since a PRG was not available for elemental mercury.
- The PRGs for carbon disulfide, 1,2-dichlorobenzene, 1,3-dichlorobenzene, ethylbenzene, styrene, toluene, 1,1,1-trichloroethane, and xylene are capped at respective Csat.

- The PRGs for anthracene, butyl benzyl phthalate, diethyl phthalate, dimethyl phthalate, and phenol are capped at the non-risk based ceiling limit of  $10^8$  ug/kg.

Inhalation of volatiles/fugitive dust in outdoor air from contaminated soil was also evaluated as a specific exposure pathway. RBSLs for this inhalation exposure pathway were obtained from the EPA Region 9 pathway-specific tables (EPA, Region 9, October 2004). The inhalation RBSL for nickel is based on nickel refinery dust. The inhalation RBSL for mercury is based on elemental mercury. Inhalation RBSLs were capped at respective Csats for carbon disulfide, 1,2-dichlorobenzene, 1,3-dichlorobenzene, ethylbenzene, styrene, toluene, 1,1,1-trichlorethane, and xylene. Inhalation RBSLs were also capped at the PRG non-risk based ceiling limit of  $10^8$  ug/kg.

EPA Region 9 PRGs for direct contact with industrial soil were not available for four non-carcinogenic constituents of concern (COCs) (acenaphthylene, benzo(ghi)perylene, 2-methylnaphthalene, and phenanthrene). COCs are those constituents that have been detected in the soil or groundwater at least once during the RFI. Consequently, RBSLs for these constituents were obtained from an applicable and appropriate source, which was from the Texas Natural Resource Conservation Commission (TNRCC) protective concentration levels (PCLs)(TNRCC, March 2006). TNRCC PCLs for non-carcinogens are computed using the same methodology as used by EPA Region 9 for PRGs. The exposure factors are also the same, with the exception of the exposed skin area and skin-absorption factor (ABS) for the dermal exposure pathway. EPA Region 9 PRGs employ a dermal exposure skin area of  $3300 \text{ cm}^2$  for adult workers and an ABS of 0.1 for semi-volatiles as recommended by EPA (2004). TNRCC PCLs employ a skin area of  $2500 \text{ cm}^2$  and an ABS of 0.13. To account for the difference so as to have equivalence with the exposure factors used by EPA Region 9, the TNRCC PCLs for the four constituents were decreased by a factor of 0.78. The resulting direct-contact RBSLs for acenaphthylene, benzo(ghi)perylene, 2-methylnaphthalene, and phenanthrene are  $2.9\text{E}+07$  ug/kg,  $1.5\text{E}+07$  ug/kg,  $2.0\text{E}+06$  ug/kg, and  $1.5\text{E}+07$  ug/kg, respectively.

RBSLs for the migration to groundwater pathway were obtained from EPA SSLs (EPA, 2002) for a dilution-attenuation factor of 20. The migration to groundwater pathway considers leaching of contaminants from soil to groundwater with subsequent ingestion of groundwater. In

accordance with EPA guidance (EPA, 1996), use of dilution-attenuation factor of 20 is appropriate for source areas less than 0.5 acre in size. All SWMU and AOC sources at SCYI are less than 0.5 acre in size.

EPA SSLs for migration to groundwater were not available for seven COCs (2-butanone, dibenzofuran, acenaphthylene, benzo(ghi)perylene, 2-methylnaphthalene, phenanthrene, and cobalt). Consequently, migration to groundwater screening levels for these constituents were obtained from TNRCC PCLs (TNRCC, March 2006). TNRCC developed migration to groundwater PCLs in the same manner as for EPA SSLs. TNRCC migration to groundwater PCLs were taken from the residential 0.5 acre source area scenario, so as to be consistent with the exposure factors used for EPA SSLs (EPA, 2002).

Additionally, the analytical results for MSL metals in soil that exceeded RBSLs were compared to background soil levels at the SCYI facility. The determination of background metal levels is discussed in Section 5.2. All of the MSL metals are found naturally in soils and their occurrence at each SWMU is not necessarily related to SCYI facility operations.

### Groundwater

The hierarchy used for selection of groundwater screening levels, which is set forth in Module 3 of SCYI's RCRA Permit, is as follows:

- EPA maximum contaminant levels (MCLs) were used as the primary groundwater screening level. For lead, the EPA action level of 15 ug/L was used.
- Where MCLs are not available, risk-based EPA Region 9 PRGs for tap water were used (EPA, Region 9, October 2004)
- For constituents that do not have MCLs or Region 9 PRGs, EPA Region 3 tap water risk-based screening levels were used (EPA, Region 3, October 2006). This occurred for cis- and trans-1,3-dichloropropane, dibenzofuran, and 2-methylnaphthalene.



- For constituents of concern where none of the above standards are available, alternative standards from TNRCC (March 2006) were used. TNRCC residential groundwater PCLs were used for groundwater screening levels for acenaphthylene (1500 ug/L), benzo(ghi)perylene (730 ug/L), and phenanthrene (730 ug/L).

Concentrations of metals in groundwater reported throughout this RFI report represent dissolved metal concentrations, except where total concentrations are specifically noted.

Arsenic detections above the EPA Region 9 tap water PRG of 0.045 ug/L, but less the MCL screening level of 10 ug/L, occurred at the following five SWMUs: Northeast Refinery Area (SWMU 40), East API Separator (SWMU 3), Dewatering Chamber (SWMU 38), West API Separator (SWMU 2), and Main Dock Sump (SWMU 33). The detected concentration at these SWMUs varied from 2.8 to 7.1 ug/L. At the Watery Oil Separator (SWMU 43) arsenic occurred at concentrations up to and including 10 ug/L. As will be discussed for the North Aeration Basin (SWMU 17) and the Barge Dock Sump (SWMU 34) in Sections 5.4 and 5.17, respectively, arsenic exceeded its MCL screening level in groundwater at these two units. It should be noted the 0.045 ug/L tap water PRG is below the reporting limit of available laboratory instrumentation.

Puerto Rico Water Quality Standards (PREQB, 2003) for groundwater protection are the same as EPA MCLs with the exception of antimony, dibromochloromethane, and 1,2,4-trichlorobenzene, for which Puerto Rico standards are lower. The PREQB groundwater standard for antimony is 5 ug/L, whereas the EPA MCL is 6 ug/L. The PREQB groundwater standard for dichlorobromomethane is 5 ug/L, whereas the EPA MCL is 80 ug/L. The PREQB groundwater standard for 1,2,4-trichlorobenzene is 9 ug/L, whereas the EPA MCL is 80 ug/L. Only antimony is a constituent of concern that has been detected at the SCYI facility. However, antimony did not exceed its PREQB groundwater quality standard.

#### Surface Water

Surface water screening levels for protection of human health were obtained from Puerto Rico Water Quality Standards (PREQB, 2003). (Surface water results were also compared to

ecological screening levels as discussed in Section 7.3). Note that the Puerto Rico Water Quality Standard for protection of human life (which is due to fish consumption) for Class SC water (coastal/estuarine water) for arsenic should be 1.4 ug/L. Class SC water is applicable to the surface water in the Turning Basin adjacent to the Main Dock Sump (SWMU 33) and Barge Dock Sump (SWMU 34).

The water quality standard for arsenic presented in PREQB (2003) appears to have a typographic error that incorrectly lists it as relating to protection of aquatic life rather than to human health. The PREQB human health standard for arsenic (1.4 ug/L) is derived from the federal human health (organism only) standard presented in 40 CFR 131.36 (0.14 ug/L at a  $10^{-6}$  risk level). Since PREQB utilizes a  $10^{-5}$  risk level for protection of human health for arsenic in surface water (Federal Registers, December 22, 1992 and October 29, 2004) the corresponding standard should be 1.4 ug/L.

### 5.1.3 Field Screening Program

A field screening program was implemented to assist the field team personnel in selecting the most contaminated soil samples at each SWMU for detailed laboratory analysis and for identifying any potentially contaminated areas. The worst-case human health exposure scenario could then be evaluated from the results of the most contaminated samples. Areas with lesser contamination as identified by the field screening, were consequently interpreted to have a lesser exposure.

Field screening methods included BTEX and PAH immunoassay techniques, visual observations and photoionization detector measurements. The three methods were used in concert to select the most contaminated samples. Field screening results also were used to determine the need to collect deeper samples for detailed analysis and for selection of an additional sample for detailed analysis at selected SWMUs in accordance with the RFI Work Plan. The detection range for the BTEX immunoassay was from about 2.5 to 35 mg/kg. The detection range for the PAH immunoassay was from about 0.6 to 25 mg/kg. The immunoassay method does not allow for quantification of concentrations above the detection range.



Of the three field screening techniques, visual observations and PID measurements correlated most closely with laboratory measurements and site environmental conditions. BTEX immunoassay results showed a detection in 22 out of the 58 samples sent for detailed laboratory analysis. The laboratory VOC results showed a detection in 4 out of the 58 samples, 2 of which corresponded to the immunoassay detections. The overall indication was that the BTEX immunoassay results were biased high. PAH immunoassay results showed a detection in 15 out of the 58 samples sent for detailed laboratory analysis. The laboratory BNA results showed a detection in 21 out of the 58 samples, 10 of which corresponded to the immunoassay detections. The overall indication was that the PAH immunoassay results were biased low.

The inherent differences between the detailed laboratory methods and qualitative/semi-quantitative field screening methods, including immunoassay, account for the variation in correlations. Although any one screening method on its own may not have provided a sample by sample correlation, when all three field screening criteria were applied in concert, the most contaminated areas were identified at each SWMU.

## **5.2 Background Soil and Groundwater Investigation**

The objective of obtaining background soil samples as part of the RFI field investigation was to determine the naturally occurring background concentrations of MSL metals in the soil in the vicinity of the SCYI facility. The objective of obtaining background groundwater samples was to determine the shallow groundwater quality at upgradient locations of the Refinery Area and the Dock Area. A comparison of analytical results of investigative samples to background levels can be used to determine if soil or groundwater has been impacted by facility operations.

### **5.2.1 Background Soil Investigation**

Background soil sampling was conducted in accordance with the procedures detailed in the 1994 RFI Work Plan and the 2002 Supplemental RFI Work Plan. A total of 18 soil samples were collected at nine boring locations identified as BG-1 through BG-9 as shown in Figure 5-2. At each location, a sample was collected from a depth of 0-0.5 ft bgl and 3-3.5 ft bgl. Soil samples from locations BG-1, BG-2 and BG-3 were collected in July 1996. Soil samples from locations BG-4 through BG-9 were collected in April 2003.

Each background soil sample was analyzed for MSL metals. Additionally, to ensure that the background soil sample locations have not been impacted by process activities, a soil sample was collected at locations BG-4 through BG-9 and analyzed for VOCs and BNAs. The sample for VOCs was collected from a depth of 1.5-2 ft bgl and the sample for BNAs from a depth of 0-0.5 ft bgl.

The results of the soil background sampling for metals are presented in Table 5-1. The laboratory identified antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, lead, mercury, nickel, selenium, and vanadium at various depths and locations. Results of VOC and BNA analysis, which detected no constituents in excess of RBSLs, demonstrate that background sample locations had not been impacted by facility operations.

Statistical analysis was performed on a data set comprising the 1996 and 2003 sampling results as well as laboratory results of background soil samples collected by Geraghty & Miller, Inc. in

June of 1992. These results are presented in Table 5-2. Statistical analysis of the data was conducted in accordance with the protocol described in the Supplemental RFI Work Plan. Documentation of the statistical analysis is presented in Appendix G.

The revised background levels for metals in soil at the SCYI facility are presented in Table 5-3.

### **5.2.2 Background Groundwater Investigation**

Background groundwater sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at two wells installed during the RFI: one northwest of the Administration Building within the Refinery Area (RA-8) and one west of the Barge Dock Sump within the Dock (DA-1) as shown in Figure 5-2. Samples were collected for BTEX analysis. Wells were installed and sampled in July 1996.

The laboratory results of the groundwater samples collected at DA-1 and RA-8 for BTEX analysis are presented in Table 5-4. BTEX was not detected at these two sampling locations.

### **5.3 Final Retention Basin (SWMU 14)**

The objective of the RFI field investigation at the Final Retention Basin was to determine if groundwater has been impacted by prior operation of the unit. This SWMU was included in the 1994 Consent Order due to the potential for impact to groundwater.

#### **5.3.1 Scope**

In accordance with the procedures detailed in the RFI Work Plan, two monitoring wells were installed downgradient of the northeastern corner of the Final Retention Basin. The wells were installed by hollow stem auger equipment at locations FRB-1 and FRB-2 as shown in Figure 5-3. Groundwater samples were collected from both wells in August 1996 and analyzed for VOCs, BNAs and dissolved metals. After the results of the initial groundwater samples were evaluated, a confirmatory groundwater sample was collected at well FRB-2 in January 1997 and was analyzed for dissolved antimony. Well FRB-2 was sampled again in April 2003 during the supplemental investigation and was analyzed for total and dissolved antimony.

In accordance with the RFI Work Plan, no soil samples were collected at this SWMU.

#### **5.3.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the Final Retention Basin generally consists of fill material described as gravelly, silty sand to a depth of a few inches followed by silty sand, sandy silt, and/or clay to the bottom of the boring. Groundwater was encountered during drilling at approximately 8 ft bgl. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at the unit is to the northeast.

#### **5.3.3 Results**

The results of the laboratory analysis for VOCs are presented in Table 5-5 and summarized in Figure 5-3. The laboratory detected 1,2-dichloroethene in samples from both wells FRB-1 and

FRB-2, but at concentrations less than the groundwater screening level for this analyte. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Table 5-6 and summarized in Figure 5-3. No BNAs were detected in either of the two monitoring wells.

The results of the metals analysis are presented in Table 5-7 and summarized in Figure 5-3. The laboratory identified barium, cadmium, chromium, and lead at various concentrations at wells FRB-1 and/or FRB-2, but at levels less than groundwater screening levels. Antimony was detected in excess of its MCL of 6 ug/L at well FRB-2 at a concentration of 54.7 B ug/L during the August 1996 sampling event, but was not detected at well FRB-1. Antimony was not detected in confirmatory samples collected at well FRB-2 in January 1997 and April 2003.

#### **5.3.4 Conclusions**

Based on the laboratory analysis of groundwater samples collected from the two monitoring wells, no groundwater screening levels were exceeded for VOCs, BNAs or metals, except for the initial result for antimony at well FRB-2, which had a concentration above the MCL and slightly above the laboratory detection limit. The January 1997 confirmatory sampling results as well as the April 2003 supplemental groundwater sampling results demonstrate that antimony is not present in the groundwater at the Final Retention Basin in concentrations in excess of its MCL of 6 ug/L. It is therefore concluded that the initially reported result of 54.7 B ug/L at well FRB-2 was a false positive, which was not representative of actual groundwater conditions.

The results of the RFI sampling program at the Final Retention Basin demonstrate that operation of the unit has not impacted groundwater in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

## **5.4 North and South Aeration Basins (SWMUs 17 and 18)**

The objective of the RFI field investigation at the North and the South Aeration Basins was to determine if groundwater has been impacted by operation of the units. These SWMUs were included in the 1994 Consent Order due to the potential for impact to groundwater.

### **5.4.1 Scope**

In accordance with the procedures detailed in the RFI Work Plan, two monitoring wells were installed downgradient of the North and South Aeration Basins at locations AB-1 and AB-2 as shown in Figure 5-4. Groundwater samples were collected from both wells in August 1996 and analyzed for VOCs, BNAs and dissolved metals. A duplicate groundwater sample was also collected from well AB-1.

After the results of the initial groundwater samples were evaluated, confirmatory groundwater samples were collected in January 1997 and analyzed for dissolved lead at well AB-1 and for dissolved antimony at well AB-2. Duplicate samples were also collected from each well during the confirmatory sampling event. In April 2003, well AB-1 was again sampled and analyzed for total and dissolved lead and well AB-2 was sampled and analyzed for total and dissolved antimony.

In accordance with the Work Plan, no soil samples were collected at this SWMU.

### **5.4.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the Aeration Basins consists of a fill material composed of silty gravelly sand to a depth of approximately 2 ft bgl and silty to sandy clay to approximately 8 ft bgl. Groundwater was encountered during drilling at varying depths ranging from approximately 8 ft bgl to 12 ft bgl. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow is to the northeast.

### 5.4.3 Results

The results of the laboratory analysis for VOCs are presented in Table 5-8 for the North Aeration Basin and in Table 5-9 for the South Aeration Basin and are summarized in Figure 5-4. No VOCs were detected in either of the two monitoring wells.

The results of the laboratory analysis for BNAs are presented in Table 5-10 for the North Aeration Basin and Table 5-11 for the South Aeration Basin and are summarized in Figure 5-4. No BNAs were detected in either of the two monitoring wells.

The results of the metals analysis are presented in Table 5-12 for the North Aeration Basin and in Table 5-13 for the South Aeration Basin and are summarized in Figure 5-4. For the August 1996 sampling event, barium, cadmium, cobalt, nickel and chromium were detected at various concentrations at wells AB-1 and/or AB-2, but at levels less than groundwater screening levels. Arsenic was detected at estimated concentrations slightly in excess of its screening level of 10 ug/L (12.3 J ug/L primary, 11.4 J ug/L duplicate) at well AB-1. Arsenic was not detected at well AB-2.

Lead was detected slightly in excess of its action level of 15 ug/L at well AB-1 at an estimated concentration of 15.9 J ug/L during the August 1996 sampling event, but was not detected in either the duplicate sample from the same well or the sample from AB-2. Lead was not detected in confirmatory samples collected at well AB-1 in January 1997 and April 2003.

Antimony was detected in excess of its MCL of 6 ug/L at well AB-2 at a concentration of 50.5 B ug/L during the August 1996 sampling event, but was not detected in the sample from well AB-2. Antimony was not detected in confirmatory samples collected at well AB-2 in January 1997 and April 2003.

### 5.4.4 Conclusions

Based on the laboratory analysis of groundwater samples collected from the two monitoring wells, no applicable groundwater screening levels were exceeded for VOCs, BNAs or MSL



metals, except for the August 1996 result for lead in the primary sample at well AB-1 and antimony at well AB-2. The January 1997 confirmatory groundwater sampling results as well as the April 2003 supplementary sampling results demonstrate that neither lead nor antimony are present in the groundwater at the North and South Aeration Basin at concentrations in excess of respective screening levels. It is therefore concluded that the initially reported exceedances of lead and antimony screening levels were false positives, which were not representative of actual groundwater conditions. Arsenic was detected at well AB-1 at a concentration only slightly above its screening level, but was not detected at well AB-2. Additionally, arsenic was not detected above its screening level at downgradient wells 40-08, 40-10, 40-11, and 40-21 (see Section 5.9).

The results of the RFI sampling program at the North and South Aeration Basin demonstrate that operation of the units have not impacted groundwater in the area. No further investigation is warranted at the units. A Corrective Measure Study is not proposed for these SWMUs.

Groundwater sampling for total and dissolved arsenic will be performed at wells AB-1 and AB-2 on a semiannual basis, however. Well AB-2 is generally downgradient of well AB-1. The sampling work will be performed as per the facility's RCRA permit requirements. (Current results from sampling events in April and September 2006, which were reported in Quarterly Progress Reports #49 and #50, showed that total and dissolved arsenic were non-detect at both wells AB-1 and AB-2).

## **5.5 Slop Oil Tank 103 (SWMU 35)**

The objective of the RFI field investigation at Slop Oil Tank 103 was to determine if the soil in the vicinity of the Slop Oil Tank is contaminated with MSL metals or petroleum hydrocarbons and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or to groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

### **5.5.1 Scope**

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at two locations identified as 35-01 and 35-02 as shown in Figure 5-5. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Samples were collected in July 1996.

A total of 12 soil samples were collected from 0 to 7.5 ft bgl for various chemical analyses from the two soil borings. Immunoassay field screening was performed on six samples for BTEX and/or PAHs from the borings. Detailed analysis for VOCs, BNAs, and/or metals was performed on samples collected from three depth intervals at location 35-01 and from three depth intervals at location 35-02 to characterize the surface and subsurface soil horizons.

In accordance with the Work Plan, no groundwater samples were collected at this SWMU.

### **5.5.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the Slop Oil Tank generally consists of fill material described as gravelly silty sand to a depth of approximately 4 ft bgl and clay to a depth of approximately 8 ft bgl. Groundwater was not encountered during drilling. Based on the site-wide groundwater level map presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 35 is to the northeast.

### 5.5.3 Results

The results of the laboratory analysis for VOCs are presented in Tables 5-14 and 5-15 for surface and subsurface soil, respectively, and are summarized in Figure 5-5. Acetone and 2-butanone were detected in samples from locations 35-01 and 35-02, but at concentrations below RBSLs. These compounds are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-16 and 5-17 for surface and subsurface soil, respectively, and are summarized in Figure 5-5. Phenanthrene was detected in a sample from location 35-01, but at a concentration below RBSLs. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Tables 5-18 and 5-19 for surface and subsurface soil, respectively, and are summarized in Figure 5-5. Arsenic was detected in surface soil at location 35-01 at a level of 2.1 BJ mg/kg, slightly in excess of its direct contact RBSL of 1.6 mg/kg. However, this level is below the site soil background level for arsenic of 8.7 mg/kg. Barium, beryllium, chromium, nickel, cobalt, lead and vanadium were detected at various depths at 35-01 and/or 35-02, but at concentrations less than RBSLs.

Although staining was noted in the surface soil at 35-01, no residual product was observed in either of the two borings drilled at the Slop Oil Tank. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-20. BTEX ranged from non-detect to 6.75 ppm; PAHs ranged from non-detect to 0.75 ppm.

### 5.5.4 Conclusions

Detailed chemical analysis of the surface and subsurface soil zones did not identify any VOCs, BNAs or metals in excess of RBSLs with the exception of arsenic, which was detected slightly in excess of its direct contact RBSL at one location. However, the level is within background levels of arsenic in soil at the site

The results of the RFI sampling program at Slop Oil Tank 103 demonstrate that operation of the unit has not impacted soil in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

## **5.6 Dissolved Air Flotation Unit (SWMU 36)**

The objective of the RFI field investigation at the Dissolved Air Flotation (DAF) Unit was to determine if the soil in the vicinity of the unit is contaminated with MSL metals or petroleum hydrocarbons and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

### **5.6.1 Scope of Work**

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at four locations identified as 36-01, 36-02, 36-03 and 36-04 as shown in Figure 5-6. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Samples were collected in July 1996.

A total of 20 soil samples were collected from 0 to 7.5 ft bgl for various chemical analyses and other physiochemical descriptions from the four soil borings. Immunoassay field screening was performed on a total of 12 soil samples from four soil borings for PAHs and BTEX. Detailed chemical analysis for TCL VOCs, BNAs and/or MSL metals was performed on samples collected from three depth intervals at location 36-02 and from three depth intervals at location 36-04 to characterize the surface and subsurface soil horizons. In addition, two samples were collected from location 36-04 for physiochemical descriptions.

In accordance with the Work Plan, no groundwater samples were collected at this SWMU.

### **5.6.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the DAF Unit consists of a few inches of fill material, unconsolidated gravel and silty clay to silty sand, to a depth of approximately 2 ft bgl and silty clay to sandy clay to sand to approximately 8 ft bgl. Groundwater was encountered during drilling at approximately 8 ft bgl at boring 36-01. The results of the physiochemical descriptions and the grain size

distribution graphs are included in Appendix H. Based on the site-wide groundwater level map presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 36 is to the northeast.

### 5.6.3 Results

The results of the laboratory analysis for VOCs are presented in Tables 5-21 and 5-22 for surface and subsurface soil, respectively, and summarized in Figure 5-6. The laboratory identified acetone, 2-butanone, ethylbenzene, methylene chloride, toluene, and xylene at various depths at location 36-02, but all at concentrations less than RBSLs. Acetone, 2-butanone, and methylene chloride are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-23 and 5-24 for surface and subsurface soil, respectively, and summarized in Figure 5-6. The laboratory identified benzo(a)pyrene in subsurface soil at a depth of 3-3.5 ft bgl at location 36-02 at an estimated concentration of 400 J mg/kg, which is slightly in excess of its direct contact RBSL of 210 mg/kg. Benzo(a)pyrene was not detected in any other surface or subsurface soil samples at the DAF unit. The laboratory also identified acenaphthene, anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenzofuran, benzo(ghi)perylene, phenanthrene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, 2-methylnaphthalene, naphthalene, and pyrene at various depths at location 36-02 and only naphthalene and pyrene in the surface zone at location 36-04, but all at concentrations less than RBSLs. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Tables 5-25 and 5-26 for surface and subsurface soil, respectively, and summarized in Figure 5-6. The laboratory identified arsenic, barium, beryllium, chromium, cobalt, lead, mercury, nickel and vanadium at various depths, but at concentrations less than RBSLs. No other metals were detected.

Staining and apparent residual petroleum product was noted at borings 36-01 and 36-04. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-27. BTEX ranged from non-detect to greater than 35 ppm; PAHs ranged from non-detect to greater than 25 ppm.

#### **5.6.4 Conclusions**

Detailed chemical analysis of soil samples at the DAF Unit detected a number of VOCs, BNAs and metals in the surface and subsurface zones. With the exception of benzo(a)pyrene, none of the constituents were detected at concentrations in excess of RBSLs. Benzo(a)pyrene was detected at one location at an estimated concentration slightly in excess of its direct contact RBSL, but was not detected in any other surface or subsurface soil sample at the DAF unit.

The results of the RFI sampling program at the DAF Unit demonstrate that operation of the unit has not significantly impacted soil in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.



## 5.7 Dewatering Chamber (SWMU 38)

The objective of the RFI field investigation at the Dewatering Chamber was to determine if the soil and/or groundwater in the vicinity of the unit are contaminated with MSL metals or petroleum hydrocarbons and, if so, to determine if the potential exists for hazardous constituent migration. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater from an apparent surface spill located to the southwest of the unit.

### 5.7.1 Scope of Work

#### Soil Investigation

Soil sampling was conducted in accordance with the RFI Work Plan at four locations identified as 38-01, 38-02, 38-03 and 38-04 as shown in Figure 5-7. The sampling locations were selected based on the distribution of surficial staining in the area. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Soil samples were collected in July 1996.

A total of 21 soil samples were collected from 0 to 9.5 ft bgl for various chemical analyses and other physiochemical descriptions from the four soil borings. Immunoassay field screening was performed on a total of 12 soil samples from four soil borings for BTEX and PAH analysis. Detailed chemical analysis for VOCs, BNAs and/or metals was performed on soil samples collected from four depth intervals at location 38-02 and from three depth intervals at location 38-04 to characterize the surface and subsurface soil horizons. In addition, two soil samples were collected from location 38-02 and analyzed for physiochemical parameters.

#### Groundwater Investigation

A groundwater monitoring well was installed at location 38-02 to collect a groundwater sample for chemical analysis and to observe groundwater levels. A groundwater sample was collected from the well and was analyzed for VOCs, BNAs and dissolved metals. The well was installed in July 1996 and sampled in August 1996.

## **5.7.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the Dewatering Chamber consists of a sandy gravel to silty gravelly sand to a depth of approximately 6 ft bgl and clayey silty sand to approximately 8 ft bgl. Groundwater was encountered during drilling at approximately 8 ft bgl. The results of the physiochemical descriptions and the grain size distribution graphs are included in Appendix H. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 38 is to the northeast.

## **5.7.3 Results**

### Soil Investigation

The results of the laboratory analysis for VOCs in soil are presented in Tables 5-28 and 5-29 for surface and subsurface soil, respectively, and summarized in Figure 5-7. No VOCs were detected in the surface or the subsurface zones.

The results of the laboratory analysis for BNAs in soil are presented in Tables 5-30 and 5-31 for surface and subsurface soil, respectively, and summarized in Figure 5-7. No BNAs were detected in the surface or subsurface zones.

The results of the laboratory analysis for metals in soil are presented in Tables 5-32 and 5-33 for surface and subsurface soil, respectively, and summarized in Figure 5-7. The laboratory identified arsenic, barium, beryllium, chromium, cobalt, lead, mercury, nickel and vanadium at various depths, but at concentrations less than RBSLs. No other metals were detected.

No staining or apparent residual petroleum product was observed in any of the soil borings. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-37. BTEX was identified at levels ranging from non-detect to greater than 35 ppm; PAHs ranged from non-detect to greater than 25 ppm.

### Groundwater Investigation

The results of the laboratory analysis for VOCs, BNAs and MSL metals in groundwater are presented in Tables 5-34, 5-35, and 5-36 and summarized on Figure 5-8. No VOCs or BNAs were detected in the groundwater. The metals arsenic, barium, cadmium, cobalt, nickel and vanadium were detected, but all at concentrations below groundwater screening levels.

### **5.7.4 Conclusions**

Detailed chemical analysis of soil samples at the Dewatering Chamber did not detect VOCs or BNAs in the surface and subsurface zones. A number of metals were detected in the surface and subsurface zones. However, none of the metals were detected at concentrations in excess of RBSLs.

Detailed chemical analysis of the groundwater sample collected at the Dewatering Chamber did not detect VOCs or BNAs. A number of metals were detected in the groundwater, but at concentrations below groundwater screening levels.

The results of the RFI sampling program at the Dewatering Chamber demonstrate that operation of the unit has not impacted soil or groundwater in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

## **5.8 Hazardous Waste Mixing Box (SWMU 39)**

The objective of the RFI field investigation at the Hazardous Waste Mixing Box was to determine if the soil in the vicinity of the unit is contaminated with MSL metals or petroleum hydrocarbons and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

### **5.8.1 Scope of Work**

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at three locations identified as 39-01, 39-02, and 39-03 shown in Figure 5-9. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Initial samples were collected in July 1996. In April 2003, as part of the supplemental field investigation, program soil samples not collected in 1996 were collected to ensure an RFI completeness goal of 100%.

A total of 14 soil samples were collected from 0 to 16.0 ft bgl for various chemical analyses from the three soil borings. Immunoassay field screening was performed on a total of seven soil samples from three borings for BTEX and PAHs. Detailed analysis for VOCs, BNAs and/or metals was performed on samples collected from four depth intervals at 39-01, one depth interval at 39-02, and two depth intervals at 39-03 to characterize the surface and the subsurface soil horizons.

In accordance with the work plan, no groundwater samples were collected at this SWMU.

### **5.8.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the Hazardous Waste Mixing Box generally consists of fill material described as gravelly silty sand to a depth of approximately 6 ft. Groundwater was not encountered during drilling. The results of the physiochemical descriptions and the grain size distribution graphs are included in Appendix H. Based on the site-wide groundwater level map

presented in Figures 2-16 and 2-17, the direction of groundwater flow at the Hazardous Waste Mixing Box is to the northeast.

### 5.8.3 Results

The results of the laboratory analysis for VOCs are presented in Table 5-38 and summarized in Figure 5-9. The laboratory identified acetone, 2-butanone, carbon disulfide and methylene chloride at various depths and locations, but all at concentrations less than RBSLs. Acetone, 2-butanone, and methylene chloride are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-39 and 5-40 for surface and subsurface soil, respectively, and summarized in Figure 5-9. The laboratory identified benzo(a)pyrene, benzo(b)fluoranthene, bis(2-ethylhexyl phthalate), chrysene, and pyrene at various depths at and location, but all at concentrations less than RBSLs. No other BNAs were detected.

The results of the laboratory analysis for MSL metals are presented in Tables 5-41 and 5-42 for surface and subsurface soil, respectively, and summarized in Figure 5-9. The laboratory identified arsenic, barium, beryllium, chromium, cobalt, lead, mercury, nickel and vanadium at various depths and locations, but at concentrations less than RBSLs. No other metals were detected.

Staining was observed at each of the soil boring locations although no evidence of residual product in soil was observed. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-43. BTEX was identified at levels ranging from non-detect to greater than 35 ppm; PAHs ranged from non-detect to greater than 25 ppm.

#### **5.8.4 Conclusions**

Detailed chemical analysis of soil samples at the Hazardous Waste Mixing Box detected a number of VOCs, BNAs and metals in the surface and subsurface zones. However, none of the constituents were detected at concentrations in excess of RBSLs.

As part routine groundwater monitoring for the equalization basin, a groundwater sample was collected from well MW-RA6 in January 1997 and analyzed it for VOCs. As shown in Figure 5-9, well MW-RA6 is adjacent to the Hazardous Waste Mixing Box and the soil sampling locations. The groundwater results, which are included in Appendix C, showed that no VOCs were detected. Data from prior sampling events at the well showed the same results.

The results of the RFI sampling program at the Hazardous Waste Mixing Box demonstrate that operation of the unit has not impacted soil in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

## **5.9 Northeast Refinery Area (SWMU 40)**

The objective of the RFI field investigation at this SWMU was to determine if the soil in the vicinity of several former waste piles in the area is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. Additionally, the area was investigated to determine if prior operation of the Old Oily Sludge Basin has impacted subsurface soil and/or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

Due to the detection of free product during the RFI, the area of soil and groundwater investigation was expanded to encompass the original SWMU, referred to as the Disposal Area Behind the Hazardous Waste Storage Area, and an area to the north of the original SWMU. This modified study area is referred to in this report as the Northeast Refinery Area.

### **5.9.1 Scope of Work**

#### Soil Investigation

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at ten locations identified as 40-01 through 40-10 as shown in Figure 5-10. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analysis for VOCs, BNAs, and/or metals was used in the field investigation. Soil sampling was conducted in June 1996.

A total of 22 soil samples were collected from 0 to 15.0 ft bgl for various chemical analyses and other physio-chemical descriptions from the ten borings. Immunoassay field screening was performed on four soil samples for BTEX and/or PAHs at locations 40-03, 40-04, 40-14A, and 40-14B. Detailed chemical analysis for VOCs, BNAs, and/or metals was performed on soil samples collected from one depth interval from locations 40-04, 40-05, 40-06, 40-07, 40-08, 40-09, and 40-10 and from three depth intervals from 40-01, 40-02, and 40-03. In addition, a sample was collected at one depth interval from location 40-14A and analyzed for



physiochemical parameters. A duplicate sample was collected from location 40-01 for VOC analysis.

### Groundwater Investigation

A total of 13 groundwater monitoring wells were installed as part of the initial RFI field investigation. Wells 40-09 and 40-10 were installed as per the RFI Work Plan after free product was discovered prior to the RFI at well MW-RA5. After free product was detected at wells 40-09 and 40-10, the monitoring well network was expanded north and downgradient as shown in Figure 5-12. The nine additional wells, which were described in work plan addendums to EPA, are identified as 40-08, 40-12, 40-14A, 40-15, 40-16, 40-17, 40-18, 40-19, and 40-20. The purpose of the additional wells was to delineate the extent of the free product and to provide additional downgradient groundwater sampling locations. The wells were installed in July 1996.

Groundwater samples were collected from locations 40-08, 40-12, 40-14A, 40-15, 40-16, 40-17, 40-18, 40-19, and 40-20 for VOCs, BNAs and/or dissolved metals. A duplicate groundwater sample was collected from temporary monitoring well 40-20 for VOC analysis. Samples were collected in August and September 1996. After the initial groundwater samples were evaluated, a confirmatory groundwater sample was collected in January 1997 at location 40-08 and analyzed for dissolved and total antimony.

As part of the supplemental investigation, groundwater samples were collected from a well cluster consisting of existing shallow well 40-14A and newly installed deep well 40-14B (see Section 4 of this report for a description of well 40-14B). Groundwater samples from these wells were analyzed for VOCs. A groundwater sample was also collected from well 40-08 and analyzed for total and dissolved antimony. In addition to the groundwater sampling conducted in accordance with the Supplemental RFI Work Plan, SCYI collected groundwater samples from wells 40-11 and 40-12. Sampling of these wells was intended to provide further support to the 1997 finding that groundwater in the vicinity of the FPH plume has not been impacted as a result of dissolution of FPH. Samples from wells 40-11 and 40-12 were analyzed for VOCs, BNAs and total and dissolved MSL metals.

In February 2005, an additional shallow groundwater monitoring well was installed at the Northeast Refinery Area in order to complete delineation of the FPH observed in the area. The location of the well, identified as 40-21, is shown in Figure 5-10. The well was sampled for VOCs, BNAs and total and dissolved MSL metals on February 23, 2005.

Slug tests were performed to evaluate the hydraulic conductivity of the water bearing zone. A product baildown test was also conducted. A sample of free product was collected from well 40-09 for chemical fingerprint analysis.

#### Surface Water and Sediment Investigation

Surface water and sediment samples were collected from Lajas Creek, which is located to the east of SWMU 40 as shown in Figure 5-10. The objective of the sampling was to determine if surface water and/or sediment have been impacted by FPH releases observed within the Northeast Refinery Area. The scope of the surface water and sediment investigation was proposed to EPA in a letter dated February 14, 2005 and was approved by EPA on March 5, 2005.

Surface water samples were collected at two locations in Lajas Creek, LC-1 and LC-2, as shown on Figure 5-10. A duplicate sample was also collected at location LC-2. Samples were analyzed for VOCs and BNAs using SW-846 Methods 8260B and 8270C, respectively. The surface water samples were collected from the middle of the creek directly into the sample bottles without any intermediate transfer devices.

Sediment samples were also collected at locations LC-1 and LC-2 in Lajas Creek. A duplicate sample was also collected at LC-2. Sediment samples were analyzed for VOCs and polycyclic aromatic hydrocarbons (PAHs). Samples were collected on February 23, 2005.

The sediment samples from Lajas Creek were collected from the top 0-0.5 ft sediment interval. The samples were collected with a coring device in order to minimize loss of fines. The samples were analyzed for VOCs using SW-846 Method 8260B and for PAHs using SW-846 Method 8270C-SIM. The 8270C-SIM (selective ion monitoring) allows for lower detection limits of

selected constituents in sediment. The sediment samples for PAH analysis were centrifuged prior to analysis to reduce moisture content (increase solids content), also for the purpose of achieving lower detection limits. The percent solids in the samples prior to centrifuging ranged from 72.4 to 78.6 percent. The percent solids after centrifuging ranged from 79.6 to 83.5 percent, and showed a moisture reduction ranging from 3.8 to 10.2 percent. Sediment samples for VOCs were not centrifuged to minimize loss of volatiles.

### **5.9.2 Site-Specific Geology and Hydrogeology**

The subsurface soil within the fenced area of the Northeast Refinery Area generally consists of a fill material composed of a mixture of gravel, sand and silt to a depth of approximately 4 ft bgl underlain by a silty clay to a depth of approximately 16 ft bgl. A clay layer was generally encountered at approximately 12 ft bgl. Groundwater was encountered during drilling at varying depths ranging from 12.5 ft bgl to 15.5 ft bgl.

The subsurface soil outside the fenced area generally consists of zones of sandy silt and sandy clay to a depth of approximately 16 ft bgl. Discontinuous sandy zones with thicknesses less than about 2 ft were encountered in several borings. In some areas, a clay zone was encountered at the bottom of the borings from between 10 to 14 ft bgl. Groundwater was encountered during drilling at varying depths ranging from 7 ft bgl to 14 ft bgl.

The results of the physiochemical descriptions and the grain size distribution graphs are included in Appendix H. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 40 is to the northeast.

During surface water and sediment sampling activities in February 2005, the width of Lajas Creek at sampling locations LC-1 and LC-2 was 8 and 7 ft, respectively. The channel width does not appear to change significantly seasonally, except during major storm events when flooding in the general area can occur. The water column depths at locations LC-1 and LC-2 were 0.6 ft and 0.1 ft, respectively. The sediment thicknesses at locations LC-1 and LC-2 were 2.2 ft and 0.2 ft, respectively. The flow rate in the creek was about 0.27 ft<sup>3</sup>/sec. The sediment at locations LC-1

and LC-2 consisted of gravelly, sandy silt with some fragments of decaying vegetation. No FPH or sheen were observed at sampling locations LC-1 and LC-2.

### 5.9.3 Results

#### Soil Investigation

The results of the laboratory analysis for VOCs are presented in Tables 5-44 and 5-45 for surface and subsurface soil, respectively, and summarized in Figure 5-10. The laboratory identified acetone, 2-butanone, carbon disulfide, methylene chloride, toluene, and/or xylene at various depths and locations, but at concentrations less than the RBSLs. Acetone, 2-butanone, and methylene chloride are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-46 and 5-47 for surface and subsurface soil, respectively, and summarized in Figure 5-10. The laboratory detected benzo(a)pyrene in subsurface soil at location 40-03 at a depth of 3-3.5 ft bgl at an estimated concentration of 2,600 J ug/kg, which exceeds the direct contact RBSL for benzo(a)pyrene of 210 ug/kg. The laboratory also identified benzo(ghi)perylene, bis(2-ethylhexyl)phthalate, chrysene, di-n-butyl phthalate, 2-methylnaphthalene, naphthalene, phenol, phenanthrene, fluorene, and pyrene at various depths at locations, but all at concentrations less than RBSLs. Bis(2-ethylhexyl)phthalate and di-n-butyl phthalate are common laboratory contaminants. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Tables 5-48 and 5-49 for surface and subsurface soil, respectively, and summarized in Figure 5-10. Arsenic was detected at levels slightly in excess of its direct contact RBSL of 1.6 mg/kg in surface soil at locations 40-02 (2.4 J mg/kg) and 40-03 (3.4 J mg/kg) and in subsurface soil at 40-03 (3.9 J mg/kg) at a depth of 3-3.5 ft bgl. However, these levels are below the site soil background level for arsenic of 8.7 mg/kg. Chromium was detected at a level slightly in excess of its migration to groundwater RBSL of 38 mg/kg in surface soil at location 40-02 (38.2 mg/kg). Nickel was detected at levels in excess of its migration to groundwater RBSL of 130 mg/kg in surface soil at locations 40-02 (153 mg/kg) and 40-03 (233 mg/kg) and in subsurface soil at 40-03 (141 mg/kg). Selenium was detected at

levels in excess of its migration to groundwater RBSL of 5 mg/kg in subsurface soil at location 40-03 (7.6 J mg/kg). Barium, beryllium, cobalt, lead, mercury, and vanadium were also detected at various locations and depths, but at concentrations less than RBSLs.

Staining and apparent residual petroleum product were noticed in the soil at locations 40-2, 40-3, 40-7, and 40-8 (within the fenced area). Staining and residual petroleum product were noticed in the soil at a number of the locations outside the fenced area. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-53. BTEX levels ranged from non-detect to 6 ppm; PAHs ranged from non-detect to greater than 25 ppm.

#### Groundwater Investigation

The results of the laboratory analysis for VOCs are presented in Table 5-50 and summarized in Figure 5-11. Acetone, carbon disulfide, toluene, and/or xylene were detected at wells 40-11, 40-12, 40-14A, and 40-14B, but at concentrations below groundwater screening levels. Acetone is a common laboratory contaminant. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Table 5-51 and summarized in Figures 5-11. 2-Methylnaphthalene was detected in excess of its screening level of 24 ug/L at well 40-21 at a concentration of 36.9 ug/L in the primary sample and 30 ug/L in the duplicate. Acenaphthene, fluorene and phenanthrene were also detected at 40-21, but at concentrations below screening levels. Acenaphthene and fluorene were detected at low levels at well 40-11, and 4-methylphenol at well 40-12, but at concentrations below groundwater screening levels. The detections at wells 40-11, 40-12, and 40-21 are likely biased high due to the presence of a sheen and/or FPH at these wells. No other BNAs were identified by the laboratory.

The results of the laboratory analysis for metals are presented in Table 5-52 and summarized in Figures 5-11. The laboratory identified arsenic, barium, cadmium, chromium, and vanadium, but at concentrations less than the groundwater screening levels. The initial antimony concentration exceeded the groundwater screening level of 6 ug/L in monitoring well 40-08 at a concentration of 57.3 B ug/L. The confirmatory sample at well 40-08 showed non-detect for antimony.

### Free Product Observations

Table 5-54 presents a summary of available FPH thickness measurements taken at monitoring wells at the Northeast Refinery Area from July 1996 to April 2006. During the initial field investigation in 1996-1997, measurable FPH was observed in several monitoring wells at the Northeast Refinery Area, which were wells 40-09, 40-10, 40-11, and 40-18. An FPH sheen or less than 0.01 ft of FPH were also observed at wells 40-12, 40-13, 40-14A, 40-15, 40-16, and MW-RA5. The maximum reported apparent FPH thickness was 1.57 ft at well 40-09 as measured between July 1996 and January 1997. No FPH was observed at well 40-20, which is located east of Lajas Creek. Wells 40-19 and 40-20 were destroyed in early 1997, respectively, by a flood and by agricultural activity. Well 40-14B was installed in February 2003 and well 40-21 was installed in February 2005.

The most recent FPH measurements from April 2006 show measurable FPH at wells 40-09, 40-10, and 40-21, and a sheen at wells 40-11 and 40-12. The maximum reported apparent FPH thickness was 1.06 ft at well 40-10. A sheen was observed at well MW-RA5 in December 2005.

Figures 5-12A, 5-12B, and 5-12C, graphically present quarterly FPH measurement data at the Northeast Refinery Area for 1997, 2001, and 2005, respectively. The locations of the monitoring wells are also shown in the figures. The area that exhibits the greatest product thickness is located north and south between wells 40-12 and MW-RA5, and east and west between wells 40-21 and 40-09. This area is also south of and between Lajas and Santiago Creeks. The FPH plume is generally stable. Visual observations have been performed on a weekly basis at Lajas and Santiago Creeks since April 2003; no sheen has been observed. The extent of residual product has been defined at this SWMU.

A product baildown test was conducted at well 40-09 during the RFI to estimate the actual formation product thickness. The results, which are presented in Appendix I, shows an estimated thickness of 0.2 ft. A product yield test conducted at the well indicated a very low recovery yield. Characterization of the free product at well 40-09 by chemical fingerprinting showed a signature indicative of severely degraded No. 4 fuel oil. Free product at nearby well MW-RA5 was also characterized as a different variety of severely degraded No. 4 fuel oil. The



specific gravity of the product was determined to be 0.92. The free product characterization results are presented in Appendix I.

#### Surface Water and Sediment Investigation

The results of the laboratory analysis for VOCs and PAHs in sediment are presented in Tables 5-55 and 5-56, respectively. Only acetone was detected in the samples at levels in excess of sediment screening levels. Since acetone is a common laboratory contaminant, its detection is attributed to a laboratory artifact. No other VOCs or PAHs were detected in the samples.

The results of the laboratory analysis for VOCs and BNAs in surface water are presented in Tables 5-57 and 5-58, respectively. No VOCs or BNAs were detected in the samples.

### **5.9.4 Conclusions**

Detailed chemical analysis of soil samples at the Northeast Refinery Area detected a number of VOCs, BNAs and metals in the surface and subsurface zones. With the exception of benzo(a)pyrene, arsenic, chromium, nickel, and selenium none of the constituents were detected at concentrations in excess of RBSLs. Benzo(a)pyrene was detected at one location in subsurface soil at a concentration in excess of its direct contact RBSL, but was not detected in any other surface or subsurface soil sample in the area.

Arsenic was detected in soil at two boring locations at concentrations in excess of its direct contact RBSL. However, the concentrations were below background levels of arsenic. Chromium was detected in soil at one boring location slightly in excess of its migration to groundwater screening level. Nickel was detected in soil at two boring locations in excess of its migration to groundwater screening level. Selenium was detected in soil at one boring location slightly in excess of its migration to groundwater screening level. Neither chromium, nickel, or selenium were detected in groundwater above screening levels at the Northeast Refinery Area, however.



The confirmatory groundwater sampling results at well 40-08 demonstrates that antimony is not present in the groundwater at the Northeast Refinery Area. It is therefore concluded that the initially reported exceedances of antimony screening levels was a false positive, which was not representative of actual groundwater conditions. Additionally, antimony does not exceed screening levels at any other groundwater sampling locations at other SWMUs.

2-Methylnaphthalene was detected in excess of its screening level at newly installed well 40-21, which is adjacent to Lajas Creek. The sample was biased high due to a sheen in the well at the time of sampling. 2-Methylnaphthalene was not detected in any other well in excess of its screening level nor was it detected in Lajas Creek surface water or sediment. The extent of impact is localized and fully delineated.

Results of the surface water and sediment investigation of Lajas Creek demonstrate that the creek has not been impacted by FPH releases within the Northeast Refinery Area.

Groundwater results from deep well 40-14B show no impact to groundwater above screening levels. This indicates that the groundwater quality further northeast and downgradient is not impacted.

As part of routine groundwater monitoring for the facility equalization basin, groundwater samples were collected from wells MW-RA6 and MW-RA7 in December 1996/January 1997 and analyzed them for TCL VOCs. Wells MW-RA6 and MW-RA7 are respectively near the southwest and southeast corners of SWMU 40 (see Figure 5-12A) and near the upgradient boundary of the unit. The groundwater results, which are included in Appendix C, showed that no VOCs were detected. Data from prior sampling events at the wells showed the same results.

A groundwater sample was collected from the Old Construction Well in April 1996 and analyzed for VOCs, BNAs, and total and dissolved metals as part of well abandonment preparations. The results are included in Appendix C. VOCs and BNAs were interpreted to be absent. Total and dissolved metal concentration were below groundwater screening levels. The Old Construction Well is screened at a deeper water-bearing zone from about 32 to 90 ft bgl. The groundwater

sampling data from this well showed that deeper water-bearing zones have not been impacted by petroleum contamination detected near the water table.

A localized FPH plume was detected on the water table at the Northeast Refinery Area during implementation of the RFI in 1996 and 1997. The FPH plume has been fully delineated. FPH is routinely monitored and recovered as part of a site-wide interim corrective measure being implemented at the SCYI facility. Historical product thickness measurements indicate that the FPH plume is generally stable.

The original objective of the RFI investigation at the Northeast Refinery Area was to determine if the soil at the unit in the vicinity of several former waste piles was contaminated with petroleum hydrocarbons or MSL metals. The results of the RFI indicate that the soil at the unit has been adequately characterized and that no further action is warranted.

Due to the presence of FPH on the water table within the Northeast Refinery Area, ongoing interim measures product thickness monitoring and recovery will continue. Additionally, groundwater sampling for 2-methylnaphthalene will be performed at well 40-21 on a semiannual basis. The work will be performed as per the facility's RCRA permit requirements.

## **5.10 West API Separator (SWMU 2)**

The objective of the field investigation at the West API Separator was to determine if the soil in the vicinity of the unit is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

### **5.10.1 Scope of Work**

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at eight locations identified as 2-01 through 2-08 as shown in Figure 5-13. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the soil investigation. Soil samples were collected in July 1996.

A total of 28 soil samples were collected from 0 to 5.5 ft bgl for various chemical analyses from the eight soil borings. Immunoassay field screening was performed on a total of 20 samples from the eight boring locations for BTEX and/or PAHs. Detailed chemical analysis for VOCs, BNAs, and/or metals was performed on samples collected from one depth interval at location 2-01, three depth intervals from location 2-02, two depth intervals from location 2-05 and one depth interval from location 2-08 to characterize the surface and subsurface soil horizons.

Due to a shallower than expected water table, soil samples were not collected from a depth of 9-9.5 ft bgl as originally required in the Work Plan, since this sample depth was below the water table. Groundwater sampling was conducted as part of the supplemental investigation in lieu of the deep soil samples. In February 2003, SCYI installed a groundwater monitoring well to evaluate if potential releases from the sides and bottom of the West API Separator have impacted groundwater. The monitoring well was installed at location 2-09, approximately 15 ft east and downgradient of the unit, as shown in Figure 5-14. The well was installed to a depth of 19.5 ft bgl, which is below the base of the West API Separator. In April 2003, a groundwater sample was collected from well 2-09 and was analyzed for VOCs, BNAs, and total and dissolved metals.

### **5.10.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the West API Separator generally consists of fill material described as gravelly sand to a depth of a few inches followed by sand to the bottom of the borings. Groundwater was encountered during drilling at varying depths ranging from 1.75 ft bgl to 3.5 ft bgl. Based on the site-wide groundwater level map presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 2 is to the east.

### **5.10.3 Results**

#### Soil Investigation

The results of the laboratory analysis for VOCs in soil are presented in Tables 5-59 and 5-60 for surface and subsurface soil, respectively, and summarized in Figure 5-13. The laboratory identified acetone at various locations and depths but at concentrations less than RBSLs. Acetone is a common laboratory contaminant. No other VOCs were detected.

The results of the laboratory analysis for BNAs in soil are presented in Tables 5-61 and 5-62 for surface and subsurface soil, respectively, and in Figure 5-13. The laboratory identified only fluoranthene and pyrene at location 2-05, but at concentrations less than RBSLs. No other BNAs were detected.

The results of the laboratory analysis for the MSL metals in soil are presented in Tables 5-63 and 5-64 for surface and subsurface soil, respectively, and summarized in Figure 5-13. Arsenic was detected in surface soil at a level slightly in excess of its direct-contact RBSL of 1.6 ug/kg at locations 2-02 (3.3 J mg/kg), and in subsurface soil at location 2-05 (3.5 J mg/kg) at a depth of 3-3.5 ft bgl, and at location 2-08 (3.2 J mg/kg) at a depth of 2.5-3 ft bgl. However, these levels are below the site soil background level for arsenic of 8.7 mg/kg. Barium, beryllium, chromium, mercury, nickel, cobalt, lead and vanadium were also detected at various locations and depths but at concentrations less than RBSLs.

### Groundwater Investigation

Groundwater sampling results are presented in Tables 5-65, 5-66, and 5-67 for VOCs, BNAs, and metals, respectively, and are summarized in Figure 5-14. No VOCs, BNAs, or metals were detected in the groundwater sample from well 2-09 above groundwater screening levels.

### Free Product Observations

No residual petroleum product was observed in any of the borings drilled at the West API Separator. Staining was noticed in the surface soil at location 2-08. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-68. BTEX was identified at levels ranging from non-detect to greater than 35 ppm; PAHs were identified at levels ranging from non-detect to greater than 25 ppm.

### **5.10.4 Conclusions**

Detailed chemical analysis of soil samples at the West API Separator did not detect VOCs or BNAs in the surface and subsurface zones in excess of RBSLs. Arsenic was detected at three locations at concentrations in excess of its direct contact RBSL. However, these concentrations were below background levels of arsenic found at the site. A number of other metals were detected in the surface and subsurface zones but all at concentrations below RBSLs.

Detailed chemical analysis of the groundwater sample collected at the West API Separator did not detect VOCs, BNAs, or metals in groundwater at concentrations in excess of groundwater screening levels.

The results of the RFI sampling program at the West API Separator demonstrate that operation of the unit has not impacted soil or groundwater in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

## **5.11 East API Separator (SWMU 3)**

The objective of the field investigation at the East API Separator was to determine if the soil in the vicinity of the unit is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

### **5.11.1 Scope of Work**

#### Soil Investigation

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at nine locations identified as 3-01 through 3-09 as shown in Figure 5-15. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Soil sampling was conducted in June and July 1996.

A total of 36 soil samples were collected from 0 to 10.5 ft bgl for various chemical analyses from the nine soil borings. Immunoassay field screening was performed on a total of 27 samples from nine locations for BTEX and PAHs. Detailed chemical analysis for VOCs, BNAs, and/or metals was performed on soil samples collected from one depth interval at location 3-01, three depth intervals at location 3-03, one depth interval from location 3-07, three depth intervals at location 3-08, and one depth interval at location 3-09 to characterize the surface and subsurface soil horizons.

#### Groundwater Investigation

Four shallow groundwater monitoring wells were installed at the East API Separator at locations 3-07, 3-09, 3-10A and 3-11 as shown on Figure 5-16. Wells 3-07, 3-09 and 3-10A were installed in June and July 1996 as per the RFI Work Plan to collect groundwater samples for chemical analyses and to observe groundwater levels. Well 3-11 was installed in February 2003 as part of

the supplemental investigation in order to complete delineation of FPH observed in the vicinity of the unit. Deep well 3-10B was also installed in February 2003 for vertical delineation and vertical gradient purposes (see Section 4 of this Report for a description of well 3-10B).

In August 1996, a groundwater sample was collected from location 3-10A and was analyzed for VOCs, BNAs, and dissolved metals. A sample from location 3-07 was collected in February 1997 and analyzed for VOCs only as sufficient sample was not available for BNA and metal analyses. A groundwater sample was not collected from well 03-09 because of the presence of FPH. In April 2003, a groundwater sample was collected from well 3-11 and was analyzed for VOCs, BNAs, and total and dissolved metals. Groundwater samples were also collected from a well cluster consisting of existing shallow well 3-10 (renamed 3-10A) and newly installed deep well 3-10B. Groundwater samples from these two wells were analyzed for VOCs.

### **5.11.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the East API Separator generally consists of fill material described as gravelly sand to a depth of a few inches followed by sand. Groundwater was encountered during drilling at varying depths ranging from 5.5 ft bgl to 8.5 ft bgl. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 3 is to the east.

### **5.11.3 Results**

#### Soil Investigation

The results of the laboratory analysis for VOCs in soil are presented in Tables 5-69 and 5-70 for surface and subsurface soil, respectively, and summarized in Figure 5-15. Methylene chloride was detected in subsurface soil at location 3-03 (48 J ug/kg) at a depth of 3-3.5 ft bgl, which exceeds its migration to groundwater RBSL of 20 ug/kg. Methylene chloride was also detected in subsurface soil at location 3-03 (5 J ug/kg) at a depth of 8-8.5 ft, but at a concentration below RBSLs. Methylene chloride is a common laboratory contaminant and is not believed to be associated with SCYI operations. Acetone and carbon disulfide were also detected at various



locations and depths, but at concentrations less than RBSLs. Acetone is also a common laboratory contaminant. No other VOCs were detected.

The results of the laboratory analysis for BNAs in soil are presented in Tables 5-71 and 5-72 for surface and subsurface soil, respectively, and summarized in Figure 5-15. The laboratory identified benzo(a)pyrene in surface soil at location 03-08 at an estimated concentration of 230 J ug/kg and in subsurface soil at location 03-01(3-3.5 ft bgl) at an estimated concentration of 1,000 J ug/kg. These concentrations exceed the direct contact RBSL for benzo(a)pyrene of 210 ug/kg. Benzo(a)pyrene was not detected in any other surface or subsurface soil sample at the East API Separator. The laboratory also identified chrysene, fluorene, naphthalene, pyrene, benzo(ghi)perylene, 2-methylnaphthalene, and phenanthrene at various locations and depths, but all at concentrations less than RBSLs.

The results of the laboratory analysis for metals in soil are presented in Tables 5-73 and 5-74 for surface and subsurface soil, respectively, and summarized in Figure 5-15. Arsenic was detected at levels slightly in excess of its direct contact RBSL of 1.6 mg/kg in subsurface soil (3.5-4 ft bgl) at location 3-01 (4.4 mg/kg), and in surface soil at location 3-03 (2.5 mg/kg) and at location 3-08 (2.5 J mg/kg). However, these levels are below background level of 8.7 mg/kg for arsenic in soil at the site. Barium, beryllium, chromium, mercury, nickel, cobalt, lead and vanadium were also detected at various locations and depths, but at concentrations less than RBSLs.

Apparent residual petroleum product was observed in soil borings at locations 3-01, 3-07 and 3-09. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-78. BTEX was identified at levels ranging from non-detect to greater than 25 ppm; PAHs were identified at levels ranging from non-detect to greater than 25 ppm.

#### Groundwater Investigation

The results of the laboratory analysis for VOCs, BNAs and metals in groundwater are presented in Tables 5-75, 5-76, and 5-77, and are summarized in Figure 5-16. At well 3-10B, 2-butanone was detected, but at a concentration below its screening level. 2-butanone is a common laboratory contaminant. No other VOCs or BNAs were found in groundwater samples collected

at this SWMU. The laboratory identified barium, cadmium, mercury and nickel in samples from wells 3-10A and 3-11, but at levels less than groundwater screening levels.

#### Free Product Observations

Table 5-79 presents a summary of available FPH thickness measurements taken at monitoring wells at the East API Separator from August 1996 to April 2006. During the initial field investigation in 1996-1997, FPH was observed in monitoring well 03-09. Maximum reported apparent FPH thickness was 0.77 ft as measured in August 1996. FPH was last observed at well 03-09 in June 2001 at a thickness of 0.23 ft. Subsequent to this, only a sheen has been observed at well 03-09. FPH has not been observed at wells 03-07, 03-10A, 03-10B, and 03-11.

Figures 5-17A, 5-17B, and 5-17C, graphically present quarterly FPH measurement data at the East API Separator for 1997, 2001, and 2005, respectively. The locations of the monitoring wells are also shown in the figures. The FPH plume is generally stable with decreasing FPH thickness. The measurements show that the extent of FPH has been defined at this SWMU and is limited to the immediate vicinity of the unit.

#### **5.11.4 Conclusions**

Detailed chemical analysis of soil samples at the East API Separator did not detect VOCs in the surface and subsurface zones in excess of RBSLs with the exception of methylene chloride, a common laboratory contaminant, at a concentration in excess of its migration to groundwater RBSLs. Methylene chloride (48 J ug/kg) was reported in subsurface soil at boring location 3-03 above its migration to groundwater RBSL of 20 ug/kg. Since the methylene chloride concentration does not significantly exceed its migration to groundwater RBSL, and since this constituent has not been detected at any of the wells at the East API Separator or at downgradient wells [wells 45-01 and 45-02 of the East Aisle Ditch (SWMU 45) and wells at the Barge Dock Sump (SWMU 34)], this constituent in soil has had no significant impact on groundwater.

With the exception of benzo(a)pyrene, no BNAs were detected in soil at concentrations in excess of RBSLs. Benzo(a)pyrene was detected at two location at estimated concentrations in excess of

its direct contact RBSL, but was not detected in any other soil or groundwater sample at the East API Separator.

Arsenic was detected in soil at three locations at concentrations in excess of its direct contact RBSL. However, these concentrations were below background levels of arsenic found at the site. A number of other metals were detected in the surface and subsurface zones, but all at concentrations below RBSLs.

Detailed chemical analysis of groundwater samples collected at the East API Separator did not detect VOCs, BNAs, or metals in groundwater at concentrations in excess of groundwater screening levels.

A localized FPH plume was detected on the water table at the East API Separator during implementation of the RFI in 1996 and 1997. The FPH plume has been fully delineated. FPH is routinely monitored and recovered as part of a site-wide interim corrective measure being implemented at the SCYI facility. Historical product thickness measurements indicate that the FPH plume is stable with decreasing FPH thickness. Groundwater sampling results demonstrate that groundwater at the East API Separator has not been impacted by dissolution of the FPH.

The results of the RFI sampling program at the East API Separator demonstrate that soil and groundwater in the area have not been significantly impacted by operation of the unit or dissolution of the FPH plume. No further investigation is warranted at the East API Separator.

## **5.12 Watery Oil Separator (SWMU 43)**

The objective of the field investigation at the Watery Oil Separator was to determine if the soil in the vicinity of the unit is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

### **5.12.1 Scope of Work**

#### Soil Investigation

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at four locations identified as 43-01 through 43-04 as shown in Figure 5-18. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Soil samples were collected in June and July 1996.

A total of 19 soil samples were collected from 0 to 7.5 ft bgl for various chemical analyses and other physiochemical descriptions from the four soil borings. Immunoassay field screening was performed on 12 samples from four boring locations for BTEX and/or PAHs. Detailed chemical analysis for VOCs, BNAs, and/or metals was performed on samples collected from one depth interval at location 43-01 and three depth intervals at location 43-03 to characterize the surface and subsurface soil horizons. In addition, two soil samples were collected from location 43-03 and analyzed for physiochemical parameters. One duplicate soil sample was collected from 43-01 for detailed chemical analysis.

The surface soil at location 43-03 was not sampled for BNAs and metals. The surface soil was sampled for VOCs, however. A discussion of the impact on the overall soil quality assessment is presented in Section 5.12.4.

### Groundwater Investigation

In July and August 1996, three shallow groundwater monitoring wells identified as WOS-1, WOS-2, and WOS-3 were installed as shown in Figure 5-19. The wells were installed to collect groundwater samples, to monitor for any FPH at the water table, and/or to monitor groundwater levels. Groundwater samples were collected from wells WOS-1 and WOS-3 in September 1996 and analyzed for VOCs.

In February 2003, three additional groundwater monitoring wells were installed at the Watery Oil Separator as part of the supplemental investigation. The locations of the wells, identified as WOS-4A, WOS-4B and WOS-5, are shown in Figure 5-19. The wells were installed to complete delineation of the FPH detected at the unit and to confirm that the FPH has not impacted shallow or deep water bearing zones in the area. Wells WOS-4A and WOS-5 are shallow wells; well WOS-4B is a deep well, which was installed primarily to evaluate vertical groundwater flow gradients at the facility, as described in Section 4 of this report.

Groundwater samples were collected from all three wells in April 2003. Samples from wells WOS-4A and WOS-5 were analyzed for VOCs, BNAs, and total and dissolved metals. The sample from well WOS-4B was analyzed for VOCs.

#### **5.12.2 Site-Specific Geology and Hydrogeology**

The subsurface soil at the Watery Oil Separator generally consists of a sand to silty sand to a depth of approximately 8 ft bgl. The results of the physiochemical descriptions and the grain size distribution graphs are included in Appendix H. Groundwater was encountered during drilling at approximately 6.5 ft bgl at most locations. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 43 is to the east.

### 5.12.3 Results

#### Soil Investigation

The results of the laboratory analysis for VOCs in soil are presented in Tables 5-80 and 5-81 for surface and subsurface soil, respectively, and summarized in Figure 5-18. The laboratory identified methylene chloride in subsurface soil at location 43-03 (7-7.5 ft bgl) at an estimated concentration of 23 J ug/kg, which slightly exceeds the migration to groundwater RBSL for methylene chloride of 20 ug/kg. Acetone and 2-butanone were also detected at various depths and locations, but at concentrations less than RBSLs. Acetone, 2-butanone, and methylene chloride are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Table 5-82 and summarized in Figure 5-18. The laboratory identified di-n-butyl phthalate and pyrene at various locations and depths, but at concentrations less than RBSLs. Di-n-butyl phthalate is a common laboratory contaminant. No other BNAs were detected.

The results of the laboratory analysis for the metals are presented in Table 5-83 and summarized in Figure 5-18. Arsenic was detected in subsurface soil at levels in excess of its direct contact RBSL of 1.6 mg/kg at locations 43-01(6-6.5 ft bgl) and 43-03 (7-7.5 ft bgl). At location 43-03 (7-7.5 ft bgl), the arsenic concentration was 11 mg/kg, which is slightly above the arsenic background level of 8.7 mg/kg. At location 43-01 (6-6.5 ft bgl), the estimated arsenic concentration was 5.6 J mg/kg in the primary sample and 4.8 J mg/kg in the duplicate sample, both of which are below background level for arsenic in soil. Barium, beryllium, chromium, nickel, cobalt, lead and vanadium were also detected at various locations and depths, but at concentrations less than RBSLs.

Apparent residual petroleum product was observed at locations 43-01 and 43-02. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-87. BTEX was identified at levels ranging from non-detect to 12 ppm; PAHs were identified at levels ranging from non-detect to greater than 25 ppm.



### Groundwater Investigation

The results of the laboratory analysis for VOCs, BNAs and metals in groundwater are presented in Tables 5-84, 5-85, and 5-86, and are summarized in Figure 5-19. Acetone and carbon disulfide were detected at wells WOS-4A, WOS-4B, and/or WOS-5, but at concentrations below groundwater screening levels. Acetone is a common laboratory contaminant. No other VOCs or BNAs were found in groundwater samples collected at this SWMU. The laboratory identified arsenic, barium, chromium, mercury, nickel and vanadium at various wells, but at levels that do not exceed groundwater screening levels.

### Free Product Observations

Table 5-88 presents a summary of available FPH thickness measurements taken at monitoring wells at the Watery Oil Separator from July 1996 to April 2006. During the initial field investigation in 1996-1997, FPH was observed in wells WOS-1 and WOS-2. The maximum reported apparent FPH thicknesses were 0.01 ft at WOS-1 in July 1996 and 0.77 ft at WOS-2 in August 1996. FPH has not been observed at well WOS-1 subsequent to the initial measurement in July 1996. The most recent FPH measurements from April 2006 show an apparent FPH thickness of 1.26 ft at well WOS-2. FPH has not been observed in well WOS-3 or newly installed shallow wells WOS-4A and WOS-5.

Figures 5-20A, 5-20B, and 5-20C, graphically present quarterly FPH measurement data at the Watery Oil Separator for 1997, 2001, and 2005, respectively. The locations of the monitoring wells are also shown in the figures. The FPH plume is generally stable. The measurements show that the extent of FPH has been defined at this SWMU and is limited to the immediate vicinity of the unit.

Characterization of the free product at well WOS-2 by chemical fingerprinting showed a signature indicative of a severely degraded residual fraction of a crude oil or of a residual grade fuel oil. The free product characterization results are presented in Appendix I.